PERCEIVER BIAS WITH FACES

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ABSTRACT

Two experiments were carried out to challenge the Direct Access explanation of the perceiver bias for faces. Both experiments utilised a perceiver asymmetry task, with bi-emotional chimeric faces, developed by Levy, Heller, Banich and Burton (1983). An alternative type of smile (closed mouth) that made the chimeras look more natural was tested against the standard chimera, but failed to increase the incidence of perceiver bias. In Experiment One the stimuli were presented tachistoscopically in either the left, centre or right visual fields. The LVF and RVF conditions prevented the lateralised direct access of information, and subsequently produced no perceiver bias. In Experiment Two the subject's head or the face stimuli were tilted to disalign retinal coordinates from the stimuli and therefore prevented the lateralised direct access of the faces but enabled central inspection of the stimuli. However no significant perceiver biases were elicited except in the 'standard' Subject Upright Stimulus Upright condition. Although the direct access explanation was not disproved some support of attentional theories was upheld.

The perceiver left bias is a tendency for subjects to perceive the left side of a face[1] to be more similar than the right side of that face to the whole face. The left bias has not been detected with stimuli other than faces (Rhodes, Ronke & Tan, 1989), which could suggest that the phenomenon is dependent on face specific perceptual processes. However the succeeding sections shall emphasise the features of certain perceptual tasks that lead to an assumption that the left bias mechanisms are not specific to face perception. Thus by investigating the processes that result in the left bias for faces, one can explore the properties of the human perceptual system.

A lateral asymmetry in the perception of faces was first demonstrated by Gilbert and Bakan (1973). Their experiment was adapted from that of Wolff (1933) in which subjects viewed a photographed face and were required to choose which of two composites most resembled that face. The composites had been formed by bisecting the face through the vertical midline and combining each resulting half-face with its mirror image. Therefore one composite was composed of two 'left' sides, and one was composed of two 'right' sides. Wolff reported that subjects had a preference for the composite created from the left side of the face. This result suggested that the observers utilised information mainly from the left side of the original face (right hemiface), but did not show whether the asymmetry was due to a feature of the stimuli or of the observers. Gilbert and Bakan, however, included a condition in which the original face was presented in mirror reversed orientation. They found that in this condition the alternative composite (from the right side of the original face in normal orientation) was selected for being most similar to the whole face. Thus it was the composite created from the side of the face lying to the observer's left that was judged to most closely resemble the original face. This provided incontrovertible evidence that the bias was due to an asymmetry of the observer and has provided the impetus for several studies, including the present one, to attempt to isolate the mechanisms that result in the perceiver left bias.

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[1] The 'side' or 'half' of the face referred to shall always be from the viewers perspective. The term 'hemiface' shall refer to the face's or the stimulus's perspective (Rhodes 1985a). Therefore the left side of the face, to the viewer, is the right hemiface.

Explanations of the Perceiver Left Bias

Gilbert and Bakan (1973) used handedness as a precursory measure of hemispheric lateralisation and found that right handed subjects, who are considered to be more lateralised than left handers, produced a left bias but left handers did not. The importance of handedness, and therefore hemispheric lateralisation has been reflected in the criteria that researchers have used to select subjects. For examples; Lawson (1978), Rhodes (1985a) and Grega, Sackeim, Sanchez, Cohen and Hough (1988) all demonstrated the left bias with right handed subjects. The explanations proffered for this asymmetry may all depend on hemispheric lateralisation at some stage of the perceptual process, therefore as a common factor lateralisation is not a useful basis on which to classify the theories. However, the accounts can be meaningfully categorised as 'visual' or 'perceptual-attentional'. Visual explanations suggest that the left bias is caused by the brain receiving asymmetrical information about the facial stimulus. For visual explanations (eg., Scanning Direction, Lateral Eye Movements, Direct Access) retinal factors are very important. Perceptual-attentional explanations assume that an equivalent quantity of information is gathered from each side of the face and that this information is equally accessible to all visual channels (eg., directional attention shifts without eye movements referenced to gravitational or corporeal coordinates, asymmetrical attention to a mental representation which is an object centered attentional asymmetry). These latter hypotheses suggest that the higher level processes required for face perception are asymmetrical. The relative value of these theories will be discussed below.

Visual Explanations of the Left bias

Scanning Direction

Gilbert and Bakan (1973) proposed that the left bias could arise from a left-right visual field scanning direction, inbuilt from our reading practices that generalised to faces. This hypothesis suggested that the first part of the face scanned by the eyes made the most enduring impression on the observer. They ostensibly disproved this theory by detecting a left bias with Hebrew University students for whom the reading direction is right-left. However their conclusion is contentious as the subjects had been learning English since the age of 13.

Lateral Eye Movements

Kinsbourne (1972, 1974) has claimed that each hemisphere is responsible for orientation toward contralateral hemispace. He states that during verbal thought, and subsequent left hemisphere activation, subjects look right but that during spatial thought and right hemisphere activation, they look left. Grega et al (1988) proposed the lateral eye movement (LEM) hypothesis as a possible explanation for the Left-Bias. By this theory the right hemisphere will be activated by the spatial nature of the face-bias task and the individual will attend or gaze more to the left side of the facial stimuli. Thus the preference or left bias that results is due to the left side of the face being observed more intently than the right side of the face. However Grega et al (1988) found that for 32 subjects there was no significant difference between the number or duration of eye fixations on the left or right sides of a face while performing the Gilbert and Bakan judgement task. The existence of task induced lateral eye movements is an important pre-condition for this explanation of the left bias, however the evidence is contradictory. Guastella,.De Gennaro and Violani (in press cited by De De Gennaro and Violani 1988) reviewed 79 studies of which 37 found right LEM's following verbal questions 6 found left LEMs and 36 found no significant difference. There were very few LEMs following spatial and easy questions . Overall there is a lack of evidence to support a lateral eye movement explanation of left bias.

Direct Access

Perhaps the most widely accepted explanation of left bias is the Direct Access account (Gilbert & Bakan 1973; Lawson 1978; Oltman, Ehrlichman & Cox 1977; Overman & Doty 1982, Rinn 1984). Due to the neural pathways of our visual system, under a condition of central fixation information in the left visual field (LVF) is relayed to the right hemisphere and right visual field (RVF) information is relayed to the left hemisphere. Information is transferred between the hemispheres via the corpus callosum but is thought to be degraded by this further passage. Consequently the left hemisphere receives higher quality right visual field information and the right hemisphere receives higher quality left visual field information. The reported right hemisphere specialisation for face processing (for review see Rhodes 1985b) and spatial tasks generally (Springer & Deutsch 1985) suggests that highly developed processes deal with the side of the face in the LVF but not with the side of the face in the RVF. Hence the advantage for the left side of the face.

From this explanation one may expect that maximising the lateral asymmetry of the visual input by controlling the viewing conditions would maximise the chance of obtaining a left bias. As central fixation would ensure that the hemispheres receive mostly information from the contralateral visual fields, fixation should be an important experimental factor if the left bias is due to direct access. Grega et al.(1988) tested the importance of central fixation by either; requiring subjects to fixate at the beginning of the stimulus presentation or not requiring fixation at all. There was no significant difference between the amount of left bias obtained in the fixation and no-fixation conditions. This result did not resolve the issue as it could be explained in two ways: that the left bias was not dependent on a direct access of visual information or that people naturally fixate centrally.

With central fixation 200 milliseconds is the upper limit of eye movement latency (Springer & Deutsch 1985) and is therefore the maximum presentation time that can be used to permit the experimenter to assume that the stimulus is (initially) contralaterally represented in the hemispheres. Most studies that obtained a left bias presented the stimuli for significantly longer periods of time than 200 milliseconds. For example: Gilbert and Bakan (1973) presented the full faces for 5 seconds and Rhodes (1985a) imposed no time limits on subjects. Grega et al.(1988) presented full face stimuli for 1, 3 or 6 seconds with the rationale that shorter viewing times will reduce the amount of visual scanning and therefore decrease the overlap of information between each hemisphere and increase the amount of left bias obtained. The results, however, showed that a slight decrease in the amount of left bias occurred with the reduced viewing times. This result could be interpreted in two ways: either direct access is not the basis of the left bias or the short presentation durations did not allow sufficient time to assimilate necessary information about the face.

The results of the above research, on the importance of central fixation and presentation durations, do not fully discredit the direct access explanation of left bias. However these experiments did show that conditions one would expect to be more favourable for direct access were not more favourable for the left bias. Rhodes (1985a, p.198) postulated that with long presentation durations "One could still argue for a direct access account so long as the fixations were symmetrically distributed, because equal amounts of information from each side of the face would have direct access to each hemisphere.". Grega et al (1988) tested this hypothesis by using a photoelectric eye movement monitor to survey the eye fixations of 32 subjects performing the Gilbert and Bakan left bias task. The study revealed symmetrical gaze distribution patterns and thus supports the explanation offered by Rhodes.

Few studies have attempted to obtain a left bias when a direct-access explanation could be ruled out. Grega, Sackeim et al (1988) claimed to have obtained a left bias when subjects viewed the target face passing behind a slit. This prevented subjects from viewing the whole face at once and required them to mentally reconstruct the face. As the visible area was equally accessible to both hemispheres the whole face would be equally represented in each hemisphere. If the Direct Access explanation was correct no left bias should have occurred. For two reasons this experiment was not very convincing. First, the 'slit' exposed 36% of the face (by width) and thus allowed the subjects to see a large portion of the face at one time, possibly enough for a direct-access based asymmetry to occur. Second, the data showed a left bias for the mirror reversed trials but not for the original orientation trials. Therefore the results did not constitute a true perceiver-based left bias, but indicated that the asymmetry was due, at least in part, to a feature of the stimuli rather than the observer.

In summary, the direct access explanation of the left bias has not been convincingly disproved. This is because much of the evidence against direct access is indirect and based on untested assumptions about how experimental conditions actually affect a subject's perception of the stimuli. For example by allowing free viewing without central fixation, Grega et al.(1988) assumed that the subjects did not centrally fixate. Likewise by reducing the presentation times to 1 second Grega et al (1988) considered that the subjects would scan the stimulus less and gain a more lateralised perception of the face. However there were no measures taken to assess the amount of eye movement, which in short durations is likely to be more asymmetrical than in long durations over which a more balanced average could be obtained. There are however, good reasons, that will be discussed below, why one could suspect the left bias to be due to a mechanism other than direct access

Perceptual-attentional explanations of the Left Bias

The explanations mentioned thus far have described possible mechanisms responsible for the perceiver asymmetry that are largely dependent on retinal factors. The direct access explanation relies on the information impinging certain parts of the retinas. The scanning and lateral eye movement theories rely on the retinas being directed to certain parts of the stimulus. This leads to the attentional theories that have recently become popular for describing the facial bias phenomenon (Grega et al 1988, Rhodes 1985a). Attentional theories propose that the bias arises from an asymmetrical directing of attention that does not rely on the retinas.

General Attentional Asymmetries

There are two hypotheses about the nature of attentional asymmetries. Kinsbourne (1975) posited that there are pre-motor attention shifts directed to the side of space contralateral to the activated hemisphere. Attention shifts are a precursor to lateral eye movements but do not necessarily result in lateral eye movements (see also Heilman, Bowers, Valenstein & Watson 1987). Such shifts of attention influence perception at a relatively early stage of processing. An alternative concept of attentional asymmetry has been proposed by Bisiach, Capitani and Porta (1985) and Nichelli, Rinaldi and Cubelli (1989). This hypothesis is that the observer forms a mental representation of the stimulus that is processed in an unbalanced manner, and consequently the bias occurs at a later stage than with the Kinsbourne model. Therefore although equivalent information will be available to each hemisphere, the information from the left or right sides of space is differentially attended to depending on the nature of the stimuli.

Support for 'perceptual-attentional' hypotheses has come from converging evidence from several different fields of research, notably; hemi-spatial neglect, line bisection tasks and asymmetrical properties of other sensory modes.

Hemi-spatial neglect

A great deal has been learned about spatial perception and attention from research with neurological patients manifesting spatial neglect (Jeannerod, 1987). The investigation of the mechanisms responsible for neglect due to lesions may reveal the features of the intact neural system that give rise to perceptual asymmetries before and after damage. Spatial hemineglect is typically due to right hemisphere damage to the parietal cortex (Kolb &Wishaw 1985). However the incidence may be just as high with left side lesions only with less severe behavioural consequences (Ogden 1987). Neglect is identified by a patients inability to detect stimuli presented in the contralesional side of space even though the sensory organs and channels are intact. The symptom of extinction is a minor form of neglect and may occur in patients that have less severe damage or that have partially recovered from full neglect (Kolb & Wishaw 1985). Patients that exhibit extinction are able to detect stimuli that are presented singularly in either visual field, however when presentations are made to each visual field simultaneously the stimulus in the contralesional visual field is neglected in favour of the stimulus in the ipsilesional field (Bradshaw, Nettleton, Pierson, Wilson & Nathan 1987).

An extinction effect was demonstrated by Ogden (1985). Focal brain-damaged subjects, some of whom had not manifested hemineglect, viewed pairs of block shapes passing behind a vertical slit presented on a computer screen. When asked to judge if the stimuli in each pair were the same or different the subjects were found to be 'extinguishing' the side of the object on the contralateral side to that of the lesion. This occurred despite the fact that viewing through the slit prevented either hemisphere from receiving more or different information than the other hemisphere. As this occurred with both left and right hemisphere damage one cannot explain it in terms of a direct access of information to a specific hemisphere that is specialized for spatial processing. However nor could this result be explained by the lack of an hemispheric mechanism that orients to the contralesional side of space (as per Kinsbourne) because the slit display prevented the stimuli from being lateralised in front of the eyes. A possible explanation is that due to their brain damage patients were unable to attend to one side of a lateralised mental representation of the blocks. This latter explanation is consistent with the Bisiach and Luzzatti concept of attentional asymmetry.

Line bisection tasks also show that the left side of a stimulus is neglected by right hemisphere lesioned subjects. These subjects indicated that the midpoint was to the right of the true centre as if they neglected the left end of the line (Bradshaw et al 1987, Heilman et al 1987).

Investigations into the basis for the neglect of stimuli in the contralesional side of space have shown that gravitational coordinates of space are an important factor. Ladavas (1987) used right parietal lesioned subjects to detect stimuli in the left or right sides of space when the head and upper body were tilted at 90^{o}. The reaction times were slowest when the stimuli appeared in the relative left side of space. This result demonstrated that the left side of space is neglected even when the retinal coordinates of space (left and right visual fields) are disaligned from the left and right of the stimuli in the gravitational coordinates of space. If the direct access of information was needed to obtain spatial neglect the tilting condition would have stopped the specific neglect of the leftward stimulus. The spatial neglect must therefore be due to a 'perceptual-attentional' mechanism.

Further evidence supporting an attentional explanation of hemispatial neglect or extinction is that the disorder has been demonstrated with visual, auditory, tactile (Bradshaw et al 1987, Heilman et al 1987) and olfactory tasks (Bellas, Novelly, Eskenazi and Wasserstein, 1988). Bellas et al (1988) reported extinction phenomena in right hemisphere damaged patients for olfactory stimuli presented to the contralesional nostril. The nerve pathways in the olfactory system are unilateral except for the trigeminal nerve which responds to pungent odours and makes a contralateral hemisphere connection. Four readily distinguished and easily identified smells were presented two at a time to the subjects. Extinction was observed for smells that were presented to the left nostril of the right hemisphere damaged subjects but not with the undamaged controls. This is surprising given the unilateral neural connections between the source of the stimuli and each hemisphere. This result was found with all types of smell including those that stimulated the trigeminal nerve. This provides strong support for a perceptual-attentional theory of hemi-spatial neglect as the Direct Access explanation fails to account for this effect.

Perhaps the most curious spatial neglect phenomenon is the example of asymmetrical attention to a mental representation reported by Bisiach and Luzzatti (1978). They asked a hemineglect patient to visualise standing in a square in Milan, of which the subject was very familiar, looking towards the Cathedral. From this 'view' the subject was asked to recall all of the shops on each side of the square. The patient could recall more shops on the ipsilesional side of the square than the contralesional side. When asked to re-perform this task but from the exact opposite imagined viewpoint (looking toward the square from the Cathedral), the shops that were contralesional but now ipsilesional were recalled better than the shops on the other side of the square! This is not a retinal-visual phenomenon as the image was constructed in the absence of immediate visual stimulation. Nor is the effect due to memory loss as the second condition viewpoint should not have changed the recall capacity of the individual depending on the orientation of the image.

A system that results in such marked perceptual asymmetries after damage may normally function with asymmetries inherent to the intact system. Research with normals shows that asymmetries are present in the undamaged brain. For example rod bi-section tasks with right handed normals reliably result in an over-estimation of the size of the left end of the rod (Bradshaw et al, 1987). Perceptual asymmetries in normals are revealed by an 'advantage' to certain parts of space yet the asymmetries of hemineglect subjects are manifested by a 'disadvantage' or neglect of certain parts of space. This suggests that the mechanism that, when damaged, results in hemispatial neglect is the same or part of the mechanism that causes asymmetries in normal subjects and during face perception. This connection has been made before by Grega et al (1988).

The occurrence of hemineglect in several sensory modalities indicates that a 'central' or universal attentional mechanism may be responsible for the asymmetry. Though the mechanism may be universal it is not a single attentional 'unit' because neglect is not bilateral but involves only certain parts of the spatial field (Rizzolatti &Carmarda 1987). This concept is consistent with the 'Kinsbournian' model in which each hemisphere directs attention to the contralateral side of space. If the left bias for faces is due to a central attentional mechanism, equivalent asymmetries should be observed with other visual stimuli and with the other sensory modalities in normal subjects. From such evidence one could infer that the left bias for faces is due, rather than to a specialised face module effect, to a mechanism that attends to parts of stimuli, differentially, based on their lateral position in space (a Kinsbourne attentional model) or in relation to the rest of the object (a Bisiach, Capitani and Porta attentional model).

Perceptual asymmetries with normal subjects

Rhodes, Ronke and Tan (1989) failed to find a left bias with animal faces or abstract paintings. However, comparable biases to the face asymmetry have been found with normal subjects doing line bisection tasks. Bradshaw et al (1987) found that subjects reliably estimated the midpoint of a line to be left of the actual midpoint. With lines ranging from 80mm to 170mm long the phenomenological middle was rated a mean 1.6% of the half lenghth left of the true middle, with right handed subjects. It would appear that the subjects were either 'neglecting' the right end of the line or they were over estimating the left side, either of which could be interpreted as a left bias.

One can draw similarities between the tasks of rod bisection and face perception in that they are tasks for which the individual develops a great deal of expertise (see Rhodes 1985b). Just as it is important to be able to tell subtle changes in a face, it is vital to be able to judge length and distinguish between distances to function in our geometric surroundings. Diamond and Carey (1986) demonstrated that the development of expertise for specific types of stimuli can alter how one perceives those stimuli. Diamond and Carey investigated the disproportionately large decrement of recognition accuracy for inverted faces compared to upright faces. The degree of impairment was greater for the inversion of faces than other visual stimuli (Diamond & Carey 1986). However, Diamond and Carey observed a comparable inversion decrement when dog experts were required to individuate dogs that were of the same breed. This demonstrates that the inversion decrement is not specific to facial stimuli, but that the human cognitive system assimilates information differently when expertise has been developed for that stimulus. It has been suggested that with the development of expertise for faces one begins to rely more on configural (relative distances of features) than isolated featural information (Diamond & Carey, 1986, Rhodes 1986). For line bisection tasks one can use only configural information. The use of configural information may be an important factor in the type of task that elicits a left bias.

Also, faces and rods are relatively symmetrical about the vertical midline. Stimulus symmetry is important as with clearly asymmetrical stimuli, for example the side view of a dog, a lateral preference task would be non sensical and could not be interpreted as a perceiver bias, but an effect resulting from the asymmetry of the stimulus.

The small number of relatively symmetrical stimuli that we have developed expertise for processing reflects the few classes of stimuli for which a perceiver bias may occur.

Stimulus Response Compatibility

In choice reaction time experiments with an array of stimuli the type of stimulus-response (S-R) pairing is an important determinant of the speed of response. More efficient pairings result in shorter reaction times and are referred to as compatible (Ladavas & Moscovitch, 1984; Ulmita & Nicoletti, 1985). Research on stimulus-response compatibility can show us how a left bias may occur due to an attentional-perceptual asymmetry rather than a visual one. Ulmita and Nicoletti (1985) reported that subjects responded to a stimulus presented in the left side of space faster when the required response was also to the left. Similarly a rightward response was more compatible with a stimulus in the right side of space. Although both the visual information and the neural connections with the hand go to the same hemisphere, this effect is not due solely to connectivity. Three experimental conditions were designed to test the importance of the visual and tactile pathways with respect to the S-R compatibility. The first condition had subjects perform a choice-reaction task when the position of the response keys was swapped, requiring a response to the side of space contralateral to the stimulus. This disrupted any neural pathway continuity between the spatial information initially in the hemisphere ipsilateral to the response key, and the responding hand controlled from the hemisphere contralateral to the response key. In this condition subjects were therefore responding away from the side of the stimulus. The second condition had subjects cross their hands as well as the response keys so that neural connectivity criteria were satisfied while subjects were still not responding to the same side as the stimulus. The final condition had subjects cross their arms only, therefore the response was made to the same side of space that the stimuli were presented in yet the swapped hand positions ensured disruption of a neural flow of reaction based in a single hemisphere. Conditions one and two slowed the reactions of the subjects to the stimuli and therefore reduced S-R compatibility. However, when the hands only were crossed the reaction times were low indicating strong S-R compatibility.

Nicoletti and Ulmita (1985) discuss two types of theory, attentional and coding, that have been used to explain this finding. This attentional theory compares with the hemispheric activation model of Kinsbourne and postulates that the S-R compatibility effects are due to a natural tendency to respond toward the source of stimulation. Therefore when the stimulus and response are in the same side the reaction is swift yet when the stimulus and response are in different sides the reaction is slowed as the natural response tendency has to be suppressed. It was postulated that this occurs because each hemisphere is responsible for attending and intending (preparation to respond) in contralateral space independently of which hand is used. Thus when a stimulus is presented in one side of space the contralateral hemisphere is activated and this mediates the input and the response so that the hand in the same hemispace as the stimulus will be favoured.

The coding hypothesis is also an 'attentional' explanation and is consistent with the Bisiach, Capitani and Porta model of lateralised mental representation. The coding model does not refer to the behavioural functions of neural structures, about which we know comparatively little. This hypothesis proposes that stimuli are encoded in a way that codes the "leftness" or "rightness" of each stimulus. Similarly responses are coded with left or right directions inherent in that code. Therefore a left coded stimulus will have an advantage for activating a left coded response as there is a degree of spreading activation or priming between the same codes. Nicoletti and Ulmita (1985) cite a study that supports this concept over the attentional theory. The experiment was of the same format as the above S-R compatibility study except that the two stimuli and the two response keys were presented in the same side of the body midline. Following the Kinsbournian attentional theory one would not expect to observe spatial S-R compatibility effects when the stimuli and responses are in the same perceived side of space. According to a coding attentional theory the stimuli and responses could still be coded to be in a left or right position relative to the other stimulus or response. As spatial S-R compatibility effects were observed only a coding explanation could be accepted.

The evidence presented by Nicoletti and Ulmita leads to the concept that our cognitive system may be capable of coding left and right sides of individual objects in space. If objects can be side coded in this way then faces too may be represented in a manner that includes left and right spatial information. Thus a face stimulus would be encoded by the perceiver so that features on one side of the face could be inherently identified as leftward and features on the other side would be coded as rightward. This is a possible explanation of how a face could be laterally represented in a way that may enable asymmetrical perceptions of that face without one half of the face only being represented in each hemisphere (ie.. in a way that would be compatible with Grega and Sackeim's conclusion, 1988; and Bisiach and Luzatti's finding, 1978). Ultimately one should aim to address the question, "why is there a bias to one side of space or to one side of a stimulus?", however initially one must determine the nature of the perceiver bias

There is much indirect evidence to support the hypothesis that the left bias is a perceptual-attentional asymmetry. Experimentally, however, there is no very convincing evidence to support an attentional explanation of the left bias. Therefore both theories are viable and an investigation is required to resolve the issue. The following experiments were performed in an attempt to validate an attentional hypothesis for the left bias whether it is based on a Kinsbournian or a Bisiach et al (1985) attentional asymmetry model.

Obtaining a Left Bias with the method used by Gilbert and Bakan (1973) proved to be elusive for the present experimenter. To rate as a perceiver bias converse biases were needed in the original and reversed orientation conditions. This required two between subject trials, and whether or not a perceiver bias was obtained depended on the results from each of those trials. In a pilot study 59 right handed subjects were split into two groups each of which performed Gilbert and Bakan face judgements from stimuli presented on two overhead projectors. Each group saw the same 16 models however the normal orientation and reverse orientation trials were balanced between the two groups. Of 16 trials, only 3 resulted in a true perceiver left bias because the asymmetries for the stimuli in one orientation were not reflected by the other trials in the reversed orientation. Gilbert and Bakan (1973), out of 20 stimuli, only obtained the original orientation left bias and the corresponding bias in the mirror reversed condition for 9 stimuli when averaged across subjects.

An alternative procedure has been developed by Levy, Heller, Banich and Burton (1983) in which the bias can be assessed on the basis of a single trial. The task requires the subject to judge which of two bi-emotional chimeras look happiest. The stimuli are created by bisecting, through the vertical midline, photographs of the same model with a happy expression and a neutral expression. The half faces are then rejoined with the corresponding half of the face with the opposite expression. Two bi-emotional chimeras result, one with the half-smile from the left hemiface and one from the right hemiface. A chimera is paired with its mirror reversed copy to form a single trial. Subjects are asked, "which of the two faces looks happiest?" (the chimera or it's mirror reversal). By selecting the face with the half smile to the left a subject would indicate that the left side of the faces was attended to more than the right side of the faces (ie.. a perceiver left bias). The advantage of this procedure is that every trial indicates a perceiver bias in comparison with the Gilbert and Bakan technique which needs two trials to obtain one bias score.

Ley and Bryden (1979) and Sackeim and Grega (1987) have shown that there is a left visual field advantage for the perception of facial expressions of emotion. Sackeim and Grega conclude that these asymmetries are a reflection of the general left side advantage for the perception of faces. This conclusion supports the claim by Levy et al (1983) that their task is an index of functional cerebral asymmetry for processing facial characteristics. Bi-emotional chimeras may be legitimately used as stimuli that maximise asymmetries between the hemifaces and consequently enhance the left bias.

For Experiment One bi-emotional chimeric stimuli were presented tachistoscopically in the left, centre and right visual fields. The LVF and RVF conditions were designed to demonstrate a left bias when the lateralised direct access of information was prevented. In Experiment Two the face stimuli were tilted to enable central inspection of the stimuli yet still prevent the lateralised direct access of the faces.

EXPERIMENT ONE

Experiment one was a modified replication of the studies by Levy, Heller, Banich and Burton (1983) and Heller and Levy (1981). The stimuli were bi-emotional chimera's and their mirror images (Levy et al, 1983). Trials were presented tachistoscopically following the task format of Heller and Levy (1981). Subjects fixated centrally and each trial was presented in either the L.V.F, C.V.F or R.V.F. It was expected that a left bias would occur with stimuli in the central visual field. By presenting trials in the left or right visual fields the centrally fixated subjects could not assimilate the visual information of each hemiface equally into each contralateral hemisphere. Thus obtaining a left bias in the L.V.F or R.V.F. conditions would disprove the direct access explanation of the bias. This result could only be explained by Bisiach and Luzatti's model of asymmetrically attention to a mental representation. Also, a hemispheric activation model could not be supported if the bias was detected in the left or right visual fields as the stimuli would not be lateralised across the midline of the subject's corporeal coordinates or spatial coordinates of space. If a bias occrred it could only be explained by an attentional asymmetry to the left side of a mental representation. Rhodes (1985a) similarly attempted to detect a left bias in subjects performing a face recognition task by presenting face chimeras in the L.V.F, C.V.F or R.V.F, but subjects did not show a left bias.

The bi-emotional chimera's used by Heller and Levy (1981) were bizarre in appearance as the smiling half faces had open mouths and the neutral half faces were closed mouthed. The experimenter considered that by using closed mouth smiles more left bias could be obtained as the more "normal" looking faces may not have been as distracting for the subjects.

METHOD

Subjects

Forty eight right handed subjects were selected from volunteers in undergraduate Psychology courses on the basis of Edinburgh Handedness Inventory (Oldfield, 1971) scores of .7 or greater. Subjects also had to attain acuity scores of 9 or greater on the Bausch and Lomb Ortho-Rater, which corresponds with a Snellen rating of 22/20.

Apparatus

Four Kodak Carousel 1010 slide projectors were mounted in a square formation 1.2 metres from a 370mm by 225mm back viewing screen. The projectors were fitted with Lafayette tachistoscopic shutters with Lafayette timing boxes that were adjustable in 100millisecond increments. The shutter initiate and projector advance mechanisms were controlled by an IDAC 1000 data acquisition and control system, programmed from a Macintosh SE computer. The IDAC had 16 digital channels of which 8 were used for output (1 for each of the 4 shutters and the 4 projectors) and 3 inputs (1 each for the start key and two response keys). The apparatus is illustrated in Figure 1.

In order to present trials in three visual fields (LVF, CVF, RVF) it was necessary to have one projector assigned to each position. The fourth projector was loaded with the fixation cross, and was focused on the central field. Both stimuli of a pair for a single trial were loaded into the same projector. The shortest duration between the removal of the first stimulus and the presentation of the second stimulus,within each trial, was dependent on the speed at which the projector could retract one slide and reload the second. This process took just under 800ms.

The subject was seated on a variable height swivel chair behind a desk to which an adjustable chin rest was attached. When in position the subject's eyes were level with the fixation cross and were 1.4 metres from the screen. At the end of the desk below the screen was a sign with the question: "Which face is happiest?" as a reminder of the task. On a moveable panel before the subject the start and response keys were mounted. They were arranged in a triangular formation with the start key to one side (see Appendix). For half of the subjects the "FIRST FACE" key was toward the top of the panel, the "SECOND FACE" key was toward the bottom of the panel and the "START" key was to the left. The other subjects used the keys in the reverse order: "SECOND FACE" top,"FIRST FACE" bottom and"START" to the right.

A closed circuit television camera was focused on the upper half of the subject's face for eye movement monitoring. The television monitor was in a room adjacent to the experimental chamber.

Two lights were mounted on the screen of the television so that a subjects response on the "FIRST FACE" key would flash the left light and the "SECOND FACE" key would cause the right light to flash briefly.

Stimuli

Twenty five models, post-graduate psychology students and one lecturer, were photographed in three poses; neutral, smiling (mouth open), and smiling (mouth closed). The experimenter and the photographer tried to elicit spontaneous smiles from the models. However, when jokes or antics failed to humour the individual sufficiently to provoke a happy face, they were photographed with a posed expression. As two types of smile were required (open and closed mouth) even the most smiling of the models had to pose their expression to some degree. The photographer aligned the model's face by eye so that an upright and straight-on picture was obtained.

The photographic prints were digitised on an Apple Macintosh computer using the Mac Vision digitising system , and a black and white video camera. Four of the models were digitised directly, without being photographed.

Two models (3 faces from each model) were rejected because of blinking in the neutral pose. If the neutral face was rejected then no stimuli were made from that model. Three open smile faces were rejected due to blurring caused by movement.

The remaining 69 faces from 23 models were printed on an Apple Image-Writer dot matrix printer and were rated for happiness content by seven judges. Three of the judges recognised one model each, and their judgements were excluded from the analysis for that model. Each face was assessed on a five point scale where 1 corresponded to "no certain trace of happiness", 2 - "slightly happy", 3 - "moderately happy", 4 - "very happy", 5 - "as happy as can be". For the model to be satisfactory the 'neutral' face had to achieve a mean rating of less than 1.5. A smiling face needed to attain a mean greater than 2.5 to be usable. One model was rated as 'happy' in the neutral condition and was discarded. Five closed-smile faces were rejected as they failed to achieve a sufficient rating.

Utilising the 'Grid and Rulers' option in the Macintosh 'Superpaint' application, the distances between points on the faces were measured to find the vertical midline of the faces. The referrence points were; i) the middles of the pupils, ii) the sides of the face at approximately cheek bone level, iii) the corners of the mouth (for neutral face) or the middle of the upper teeth (for open smiles). There was no third reference point for closed mouth smiles as the lower face features were relatively destablised due to the expression. By calculating the mid-points of these distances and visually finding the line of best fit, the faces were bisected through the mid sagittal axis. One model was discarded because of head rotation about the vertical axis. This was detected by a difference of 2mm or more between the two halves of a face measured from the face midpoint to the side of the face. A difference of 2mm or more between the midpoints was interpreted as an indication of head tilt in the model and was the criterion for rejection of a further two models.

There were 52 suitable faces supplied by 20 models. Each bisected half-face was 'copied' and 'pasted' onto the appropriate half of another expression from the same model. The neutral left half-face was always paired to the happy right half-face and vice versa. The two half faces were realigned, by eye, with reference to the nose and eyes. Obvious seams were concealed by carefully adding or removing screen dots to make the face complexion consistent from one side of the composite to the other.

The completed bi-emotional chimeras and the mirror reversed copies were printed on an Apple Laser-Writer-Plus printer, and converted into black and white slides. When projected onto the screen the faces were between 105mm and 115mm wide, excluding the ears. The heights of the faces were more varied due to differences in hair height and fringe length, however they were approximately between 180mm and 220mm high. Displayed in the left or right visual field, the far side of a face was 4.3^{o} to 4.7^{o} from the fixation cross. The middle of a face in the left or right visual field was a mean of 2.5^{o}

from the fixation cross. Thus faces presented in the central visual field subtended a mean angle of 5^{o}.

Pairing the composite with its mirror image formed one experimental trial. Each smile-type from each model gave rise to 2 composites and therefore 2 trials: one trial in which the half smile originated from the right side of the models face (I will call this the right composite trial), and one trial from the left half of the face (the left composite trial). There were an excess of open smile composites and two models, that did not produce closed mouth smiles, were randomly removed. The experimental set consisted of 15 open and 15 closed mouth smiles from 6 male and 12 female models. Twelve models, 4 male and 8 female, produced satisfactory open and closed mouth composites. A model from whom only a single satisfactory smile was obtained was paired with a model that had produced only the other smile type. Thus, for the purpose of allocating stimuli to visual fields and balancing trials, these pairs were treated as if they were different smile types from the same model. From these 30 faces, 60 experimental trials were produced (one slide with chimera + one slide with mirror reversal = 120 slides). A further 9 trials (18 slides) were made for the practice session from rejected stimuli.

Procedure

On entering the laboratory the subject's vision was tested on the Ortho-Rater. The right eye, left eye and both eyes were tested at near and far distances in six tests of acuity (with glasses if needed). The tests required the subject to report the position of a small checkerboard in either the top, bottom, left or right of a square pattern. Each test had 12 steps of progressive difficulty.

Standard instructions were read by every subject. The experimenter demonstrated the use of the equipment and gave a verbal description of the task. Subjects were informed that the purpose of the research was to assess visual discrimination of faces, and that they were to identify which of two successively presented faces looked happiest. They were told that the differences between the faces within each trial were subtle and that looking at the face 'overall' rather than featurally would be most effective. This suggestion was intended to distract subjects from isolating features that could reveal the second face of the pair to be a mirror image. Further, the subjects were directed, when indecision prevailed, to 'guess'.

The subject initiated each trial by pressing the "START" button and then fixated on the cross that appeared for 800 milliseconds in the centre of the screen. This eye position was held for the duration of the stimulus presentations of each trial (2seconds). After the removal of the fixation cross the first face in the stimulus pair was presented, for 200milliseconds. This was followed by the fixation cross for a further 800ms after which the second face of the pair was presented for 200ms. It was not posible to replicate the Heller and Levy (1981) display times of 200,150,200,150 milliseconds due to the 100ms increments of adjustment with the shutter timers and the 800ms required to advance the slides. Following the stimulus presentation the subject pressed one of two response keys ("FIRST" or "SECOND") to indicate his or her choice of the happiest face in the trial. It was emphasised that speed was not important but that care should be taken that the intended button was pressed. The experimenter manually recorded the subjects choices from the response lights. Subjects alerted the experimenter when the wrong button was pushed so that a correction could be made.

Within each trial the sequential presentation of the stimuli to the same visual field position on the screen made the control of eye movements important. Eye movement latency is approximately 200ms (Springer & Deutsch, 1985) so although movements may occur the stimulus will normally have disappeared by the time the saccade has been initiated. Also the fixation point reappearing on the screen would encourage the recentering of the fixation. However to ensure that eye movements did not confound the results the experimenter monitored the subjects eyes through a closed circuit television during each trial. A trial was omitted from the data if the eyes moved during the stimuli presentation of that trial. Prior to data-gathering the efficacy of eye monitoring was tested with the help of an accomplice. The accomplice constructed two 30 trial tests. For the first test the observer monitored the accomplices eye movements for 30 3-second intervals. The accomplice moved her eyes in 50% of these trials in a randomised order to the left or the right side of the fixation cross. The movement, to the middle of a face projected in the two side fields, was 60mm on the screen or a visual angle change of

2.5^{o}. The second test was of the same format but the movements, to the nearest eye of a face displayed in the left or right visual field positions, were over a 35mm distance or a visual angle of 1.5^{o}. The observer tabulated the intervals in which movement was detected with 100% accuracy in the first test and 93% accuracy for the second test.

An experimental session consisted of a practice block and two experimental blocks. The practice consisted of 9 trials, 3 in each visual field position, using the stimuli rejected from the main experimental set. Each experimental block consisted of 30 trials, 10 in each visual field. The blocks were separated by a rest of 2-3 minutes.

Within each experimental block (block 1 and block 2) a third of the trials were presented in each visual field (L,M,R). Within each visual field half of the trials were left composites and half were right composites. The stimuli were assigned to block 1 or block 2 for each subject so that the left and right composite trials for one smile-type from a single model were never in the same block. Therefore a subject that saw a left composite trial of a particular model in block 1 was shown the right composite trial for that model in block 2. This was an attempt to reduce the likelihood of subjects suspecting that they had seen the same stimulus pair previously and trying to imitate their initial answer, as the left and right composite trials were very similar.

Also within each visual field half of the trials began with the original orientation composite and half began with the mirror reversed composite. This was balanced as far as possible by smile type and left, right composite trials between blocks and between subjects. When both open and closed stimuli had been produced from a single model, a trial of each type was presented in the same visual field within each block. This enabled the effectiveness of the two types of smile for obtaining a left bias to be compared.

The models were randomly divided into three equal visual field groups. Each visual field group was assigned to a projector cartridge. Models in the same group were presented in the same visual field. Moving the cartridge to another projector enabled that group to be presented in another visual field. There were two such allocations of models to groups, A B C and A' B' C', one for each half of the subjects. The presentation of a group in each visual field was balanced across visual fields between subjects: for one sixth of the subjects the visual field groups A, B and C were presented in the left, middle and right visual fields respectively, for one sixth of the subjects A, B and C were in the middle, right and left visual fields respectively, for one sixth of the subjects A, B and C were in the right, left and middle visual fields respectively. Likewise the visual field groups; A', B' and C' were balanced across the visual fields for the remaining half of the subjects.

The order of the visual fields (left, middle, right) in which the trials appeared was randomised by individually selecting 30 counters (10 representing each visual field) from a container, so that there was one order in which the projectors could be activated.

On completion of the experimental task subjects were given a verbal explanation of the aims and theory behind this research and rewarded with a chocolate fish. The testing and experimental procedure took 20 minutes.

RESULTS

The percentage of trials on which a left bias occurred (the composite with the smile to the left was chosen) was calculated for each cell of the design for each subject. A score of 50% indicates no bias. Scores above 50% represent a left bias and scores below 50% are right biases. Table 1 shows the mean percentages of left bias that occurred in each of the experimental cells.

		BLOCK ONE		BLOCK TWO	
Visual Field:	Smile Type:	Left hemiface	Right hemiface	Left hemiface	Right hemiface
LVF	Open	45.1	46.5	50.3	51.1
	Closed	46.2	45.8	45.3	54.9
CVF	Open	52.2	58.4	58.3	54.9
	Closed	44.4	49.0	51.7	50.3
RVF	Open	52.1	50.4	51.4	52.9
	Closed	44.1	46.9	52.8	55.2

Table 1): Mean percentage of trials for which a left bias was obtained in each experimental condition.

Overall Analysis of Variance

A 2x2x3x2 analysis of variance was performed on the percentage scores. There were no between subject factors. The within subject factors were experimental block (one & two), hemiface that the smile came from for the chimera (left or right), visual field (left, central or right) and smile type (open or closed).

The mean percentage of trials that elicited a left bias in blocks one and two was 48.4% and 52.4% respectively (see Table 1, Figure 1). This difference was significant, $F(1,47) = 4.60$, $p < .05$, suggesting that there was a shift towards a left bias as the experimental session progressed.

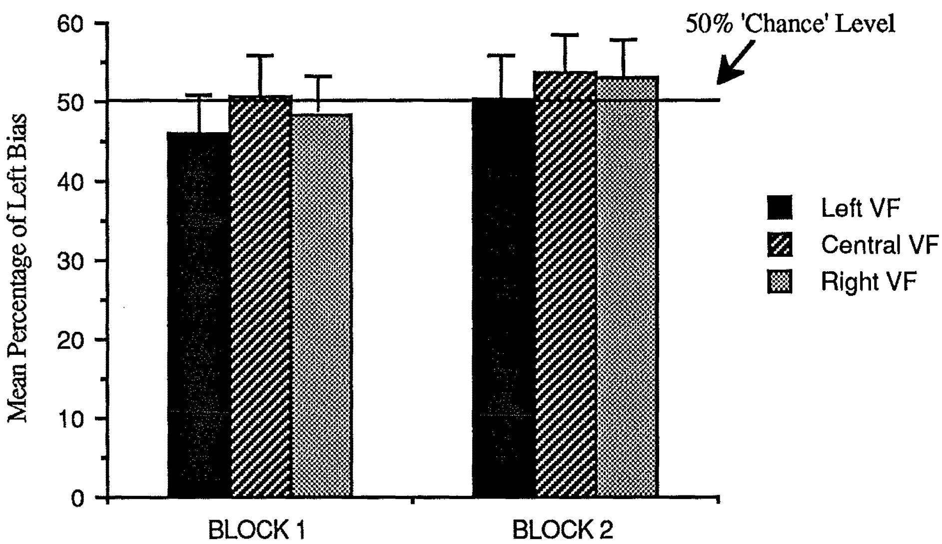

Figure 1): Mean percentage of left bias in Left, Central and Right visual fields for Blocks 1 and 2.

The mean percentages of left bias for the two hemifaces used in the composites was 49.5% for the left hemiface (the side normally to the obsevers right and 51.3% for the right hemiface (normally to the observers left). This difference was not significant, $F(1,47) = 1.14$, ns. There was no significant main effect of visual field, $F(2,47) = 1.54$, ns, (LVF = 48.1%, CVF = 52.4%, RVF = 50.7%). This result suggests that the left bias scores were not dependent on the visual field that the stimuli were displayed in. The two smile types produced mean scores of 52.0% (open smiles) and 48.9% (closed smiles). This difference was marginally significant, $F(1,47) = 2.96$, $p < .10$, indicating that the open mouth smile composites may be more effective stimuli for eliciting a left bias than the closed mouth composites. The overall mean percentage, 50.4%, was not significantly different from the 50% chance level of responding $t(47) < 1$, ns.

Block Two Analysis of Variance

Because the percentage of left bias was greater in the second experimental block an analysis of variance was conducted using this data only. The rationale was that the visual field, hemiface and smile type effects could be clearer in block two given the overall increase in the level of bias in this second half of the experimental trials. However no significant main effects or interactions were observed in the block two data, all Fs < 1, ns. The overall bias of 52.4% in block two did not differ significantly from 50%, $t(47) = .5$, ns. The mean percentage bias in the three visual field conditions in Block Two were: 50.4% (Left VF), 53.8% (Central VF) and 53.1% (RIght VF), there was no main effect for visual field, $F(2,47) = .462$, ns.

Central Visual Field Analysis of Variance

Because there was no significant left bias obtained in the two peripheral visual fields further analysis of results was focused on the Central Visual Field condition. A 2x2x2 analysis of variance was performed with three within subject factors, Block (one & two), Hemiface that the smile for the composite came from (left or right) by Smile type (open or closed). There were no main effects for Block, $F(1,47) = .742$, ns, or Hemiface, $F(1,47) = .244$, ns. There was a significant difference between the open and closed smile conditions: mean biases were 55.9% and 48.9% respectively, $F(1,47) = 4.58$, $p < .05$ (see figure 3). These two means were compared to the chance level of 50%. The open smile mean of 55.9% was significantly different from 50%, $t(47) = 2.24$, $p < .05$. The closed smile mean of 48.9% was not significantly different from 50%.This result showed that a left bias was obtained in the central viewing condition with Open smile composites as used by Heller and Levy (1981). Figure 2 shows the greater percentage of left bias that occurred with open mouth smiles compared to closed mouth smiles in the central viewing condition.

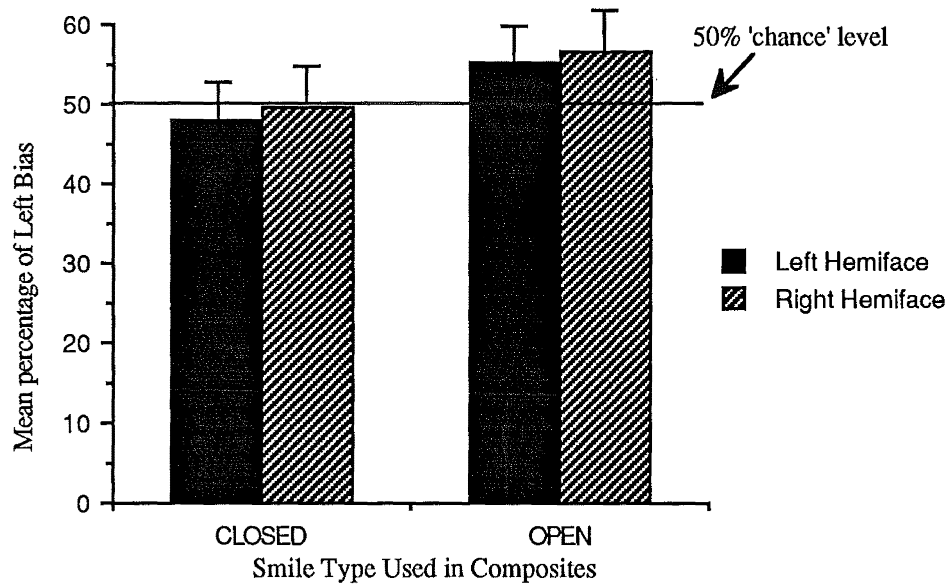

Figure 2): Mean percentage of left bias obtained with Closed or Open smile composites in the Central Visual Field only.

DISCUSSION

The percentage of left bias was greater in the 2nd Block of trials suggesting that the perceptual mechanism responsible for the bias was enhanced with priming (practise) or that the subjects needed practise with eye movement controlling before they could concentrate sufficiently on the judgement task.

As subjects were required to restrain their natural eye movements during the stimulus presentation of each trial the experiment demanded the acquisition of a degree of self control. The learning of this control may have needed more than the 9 practise trials provided prior to experimental trials. Subsequently, as subjects in the earlier trials were unable to to pay full attention to the face judgement task, the percentage of left bias was lower in Block one. An alternative explanation for the difference between the two Blocks is that the spatial processing mechanism responsible for the left bias needs to be primed and only becomes engaged after several trials. This alone is not a likely cause however as previous researchers did not report the need for abnormally long practise sessions in order to elicit a left bias. A combination of such priming effects with practise could have lead to the difference between the two Blocks.

The closed mouth smile stimuli produced more natural expressions than the open mouth stimuli when compsed into chimeras with a neutral half face. This however was not an important stimulus quality for obtaining a left bias. The open mouth smile faces, before bisection, were given happier ratings than the closed mouth smiles. Maximum contrast between the two hemifaces in the chimera therefore seems to be an important factor with respect to the left bias.

The only significant left bias was obtained in the Central Visual Field with open smile stimuli. This result is consistent with both the direct access model and the hemispheric activation model for the left bias. The asymmetrical attention to a mental representation hypothesis was not supported as no bias occurred when the stimuli were completely in the left or right sides of space and the left or right visual fields.

Requiring subjects to gain control over their eye movements was a major drawback with this experimental procedure. It soon became apparent that this requirement distracted subjects from the face judgement task. All present attempts to obtain a left bias with stimuli disaligned from lateralised retinal coordinates have increased the difficulty of the face perception task. This experiment, by presenting trials in peripheral vision, was no exception. Therefore the additional demand of eye control may have made the subjects task simply too difficult.

Tachistoscopic tasks optimise the hemispheric split of information, however due to the nature of tachistoscopic presentations they are likely to detect visual asymmetries that can be explained by low level perceptual proccesses rather than higher level asymmetries. For this reason a free-viewing task that prevented the direct access of visual information was required. The procedure most likely to succeed in demonstrating a left bias in 'non-retinal' conditions will allow the subjects to pay full visual and perceptual attention to the faces.

EXPERIMENT TWO

The aim of experiment two was to obtain a left bias when subjects viewed the bi-emotional chimeras in a central viewing field without the left and right hemifaces being aligned with retinal coordinates of space. This could be achieved by tilting the faces while the subjects remained upright. The chimera and its mirror reversal were presented simultaneously as by Levy et al (1983). Disalignment of the retinal and spatial coordinates prevented the direct access of visual information and therefore allowed the stimuli to be displayed for longer periods, than in Experiment one's tachistoscopic study. The benefit of a long presentation duration.is that the experimenter can be sure the subject had time to assimulate the stimulus.

There were four between subject experimental conditions: one; Subject Upright Stimulus Upright, two; Subject Upright Stimulus Tilted, Three; Subject Tilted Stimulus Upright, Four; Subject Tilted Stimulus Tilted. As there were conditions in which either the subjects head and/or the stimuli were tilted it was possible to test the importance of gravitational and corporeal coordinates of space versus retinal coordinates of space for obtaining the left bias. If the left bias is dependent on the face being lateralised across retinal coordinates a left bias would only occur when the subject and the stimuli are aligned, thus supporting direct access. If retinal coordinates are not vital then the bias may occur when the subject and stimulus are disaligned and an attentional hypothesis could be accepted.

The outcome in each experimental condition could contribute to our understanding of the left bias for faces. A significant left perceiver bias was anticipated for the first condition as this was a replication of Levy et al (1983). A significant left bias in the second and third conditions would indicate that the bias does not require alignment of retinal coordinates and would squash a direct access explanation of the bias. A significant left bias in the fourth condition would support the direct access theory.

An important consideration with tilting face stimuli is that they become difficult to interpret when rotated. Therefore the competing requirements of minimum rotation of the faces from upright and maximum disalignment with retinal coordinates had to be compromised. For the present study the rotation angle of 60^{o} was chosen on the basis of research by Valentine and Bruce (1989, in press) on the recognition of tilted faces. Their data indicated that face recognition performance dramatically deteriorated at the 90^{o} tilt. Although a 90^{o} tilt maximises the disalignment of gravitational from retinal coordinates it could also make the face perception process too difficult to obtain the subtle left-bias effect. A 60^{o} tilted face is easier to recognise and sufficiently disaligns the two coordinate systems so that each of the two sides of the face could not be said to lie in either the left or right visual fields.

METHOD

Subjects

Sixty four right handed subjects were selected, from undergraduate volunteers, using the same criteria as with experiment one. These individuals had not participated in the previous experiment.

Apparatus

A single slide projector fitted with a tachistoscopic shutter was mounted 1.4 metres behind a 870mm x 870mm rear viewing screen. The subject sat 1.5 metres from the screen in a swivel chair, on the back of which a head tilting guide had been attached. The functional feature of the guide was a board of wood that could be fixed at a 0^{o} tilt, a 66^{o} left tilt or a 66^{o} [2] right tilt from the vertical. The device was positioned to just touch the subjects shoulder and the side of his/her head. Thus in the 'head upright' conditions the tilt guide acted to discourage head tilting, and in the 'head tilt' conditions the guide served as a platform on which the subjects could comfortably rest their head at the correct angle to the stimuli. Subjects were not restrained in the head tilting apparatus and were able to terminate the experimental session at any time.

The start and response keys were positioned so they could easily be operated by the subjects. The keys were labelled so that the "TOP FACE" key was in the upper half of the panel and the"BOTTOM FACE" key was in the lower half of the panel. The "START" key was in the right of the panel. The two response keys activated a single light each when pressed. The two response lights were mounted before the experimenter in an adjacent room.

Stimuli

The stimuli were created from the open mouth smile bi-emotional chimeras used in experiment one with the addition of a single model to produce a total of 16 models.

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[2] Although the stimuli were tilted at 60^{o} the head was tilted at 66^{o} to allow for the 10% counter rotation of the eyes in the sockets (Corballis, 1978). Thus when the head tilts 66^{o} the eyes are at approximately 60^{o}.

The closed mouth smile composites were excluded as they appeared to be less effective in obtaining a left bias than the open mouth composites.

Slides were composed with a chimera and its mirror reversal directly beneath it. Thus the stimulus for each trial was the 5 second presentation of a single slide on which there was a composite and its mirror reversal. The tilted stimulus slides were similarly constructed but with the two faces (one top one bottom) at a 60^{o} clockwise tilt. For each stimulus pair (chimera and mirror image) two slides were made; one with the original orientation composite at the top and one with the original at the bottom. When projected the chimeric faces measured a mean of 180mm high and 100mm wide and, upright, subtended a mean visual angle of 4^{o}.

From each of the 16 models a left and a right composite was composed from which two types of trial were produced (upright, tilted) with counterbalancing for the top and bottom position in the slide. This gave a total of 128 slides for 128 possible trials. The tilted slides could be used for left or right directional tilts by flipping their position in the projector carousel.

Each subject was shown 32 trials consecutively. The trials were organised into two equivalent blocks each of 16 trials (one of each model) of which 8 were left composites and 8 were right composites. Half of the left composites and half of the right composites had the original orientation chimera as the top face. The side of face used for the smile in the composite was balanced between blocks so that when the left composite for a model was used in the first block the right composite for that model was used in the second block. For half of the second 16 trials the original orientation chimera, for a particular model, was in the same position in the slide (top or bottom) for that model in the first 16 trials. The first and second 16 trials were ordered randomly.

The position of the original orientation composites in each slide was balanced between subjects. For the upright stimuli and the tilted stimuli there were two randomised orders of the trials, each was also shown in reverse order to create eight trial orders. Therefore each upright trial order was shown to 8 subjects half of whom were upright and half of whom were tilted. Each of the tilted trial orders were shown to 8 subjects. However, the balancing between left and right tilt directions required the slides to be horizontally flipped for half of the subjects causing the swap of the original orientation position within the slide. This meant that effectively there were 8 trial 'combinations' for the tilted stimuli, each seen by 4 subjects, half of whom were tilted.

Procedure

At the beginning of an experimental session each subject was given a vision test by the method described in experiment one.

The subject was seated in the experimental chair and read a standard set of instructions (refer appendix). The experimenter also explained the task and ensured that the subject's head was correctly aligned by the head tilting chair. A practice trial constructed from rejected stimuli was used to demonstrate the operation of the apparatus. Pressing the 'START' button initiated each trial and the stimulus of a bi-emotional chimera and its mirror reversal were presented on the screen for 5 seconds. The subject judged which of the two faces appeared happier and responded by pressing the appropriate key on the panel, 'TOP FACE' or 'BOTTOM FACE'.

There were four experimental conditions: 1)Subject Upright Stimulus Upright, 2) Subject Upright Stimulus Tilted, 3) Subject Tilted Stimulus Upright and 4) Subject Tilted Stimulus Tilted. Each subject experienced only one experimental condition. The same 32 trials were shown to every subject except that trial order and the positions of the original and mirror reversed composite were balanced between subjects.

The experimenter monitored the response lights and recorded the subjects responses. The procedure took approximately seven minutes. Subjects were rewarded with a chocolate fish and were given a written outline of the theory and aims of the experiment.

RESULTS

A bias score was calculated for each subject using the following formula:

Bias score = (no of left biased trials) - (no of right biased trials) / total no of trials

A positive score indicated a left bias for the faces and a negative score denoted a right bias. The use of bias scores enabled the clear visual presentation of the results for each subject and each experimental condition (see figure 4, graphs 1 to 4. Table 2 represents the mean bias scores obtained in each experimental cell.

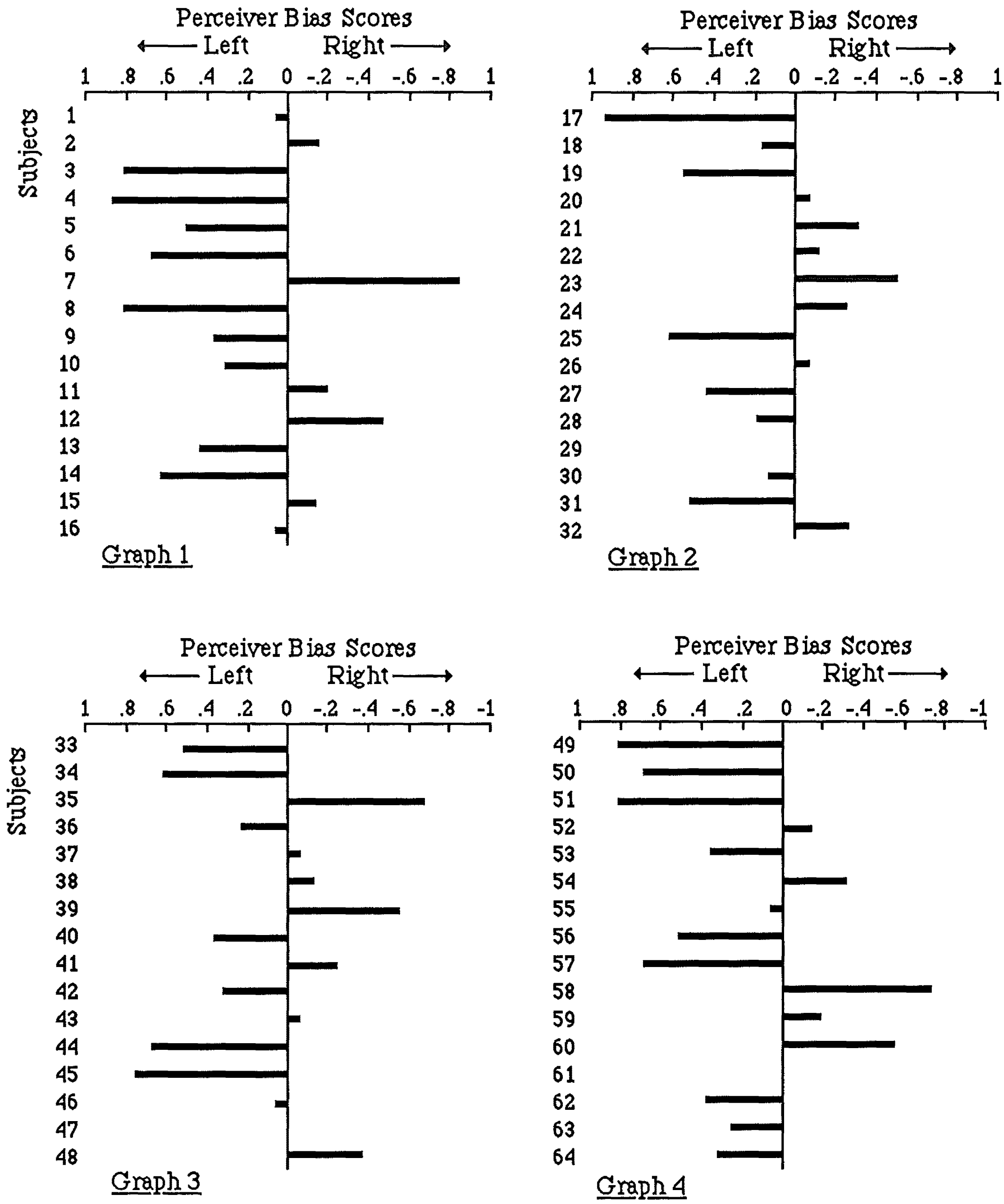

Figure 4): Graphs of the distribution of perceiver bias within each of the four experimental conditions. Graph 1) - Subject Upright Stimulus Upright, Graph 2) - Subject Upright Stimulus Tilted, Graph 3) - Subject Tilted Stimulus Upright, Graph 4) - Subject Tilted Stimulus Tilted.

Subjects Head Tilt (degrees)	Stimulus Tilt (degrees)	Right Hemiface	Left Hemiface	Mean:
0	0	.20	.29	.24 *
0	60	.15	.09	.12 ns
66	0	.02	.16	.09 ns
66	60	.19	.18	.18 ns

Table 2): Mean bias scores for each experimental condition.
* Statistically significant difference from a '0' or chance level, $p<.05$,
ns, not significant.

Overall Analysis of Variance

An analysis of variance was conducted with two between subject factors, Head Angle (2 levels) and Stimulus Angle (2 levels), and one within subject factor, Side of Hemiface used in the Composite (2 levels). There were no significant main effects, all Fs< 1.5. The mean bias scores (from Table 2) can be averaged in the Stimulus Upright conditions to give the mean bias score for the Left Hemiface (.11) and for the Right Hemiface (.23). These hemiface by stimulus orientation mean bias scores represent a significant interaction between the tilt of the stimulus and the hemiface that the smile for the composite came from, $F(1,60) = 4.14$, $p<.05$ (see Figure 3). This interaction indicates that the amount of left bias obtained was reduced by tilting left hemiface stimuli but was increased by tilting right hemiface stimuli.

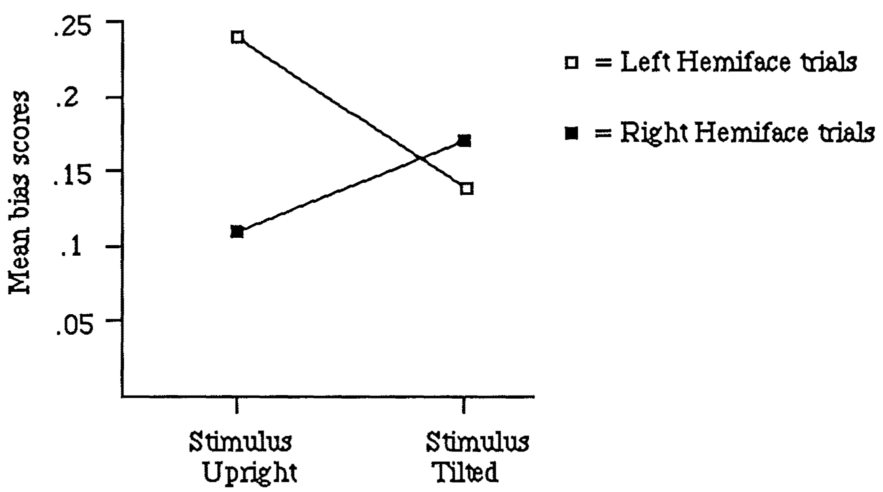

Figure 3): The interaction between the Hemiface used for the composite and the orientation of the stimulus.

The mean bias scores for each experimental group were: .24 (Subject Upright Stimulus Upright), .12 (Subject Upright Stimulus Tilted), .08 (Subject Tilted Stimulus Upright) and .18 (Subject Tilted Stimulus Tilted). T-test comparisons for each group with the chance level (0.0) showed that a significant left bias only occured in the Subject Upright Stimulus Upright condition, $t(15) = 1.97$, $p < .05$, and a marginally significant result in the Subject Tilted Stimulus Tilted group, $t(15) = 1.53$, $p < .10$.

Binomial comparisons with chance level of responding

A binomial critical level of significance was calculated for 32 trials given a chance level of responding. At the $p<.05$ level, for a Type 1 error, gaining a bias in one direction for 22 trials could be regarded as significant. In the Subject Upright Stimulus Upright condition there were 8 subjects that displayed a significant left bias and 2 displayed a right bias. In the Subject Upright Stimulus Upright condition 5 subjects produced a left bias and 1 subject had a right bias. In the Subject Tilted Stimulus Upright condition 5 subjects showed a left bias and 2 showed a right bias. In the Subject Tilted Stimulus Tilted condition 7 subjects showed a left bias and 2 subjects showed a right bias. A Chi-square analysis was performed on the proportions of subjects that displayed a significant left bias between the conditions, no significant effects were detected, sum chi^2.= 5.15, ns.

DISCUSSION

A significant group left bias was only obtained in the 'conventional' Subject Upright Stimulus Upright condtion.

Previous researchers have reported a greater occurrence of left bias with mirror reversed stimuli, that is when the smiling half of the left hemiface composite is in the left visual field (Heller & Levy 1981, Rhodes 1985a). This effect is thought to be due to the right side of the face being more expressive. The stimulus-angle by hemiface interaction, that was due to the large amount of left bias that occurred with left hemiface composite trials in the Stimulus Upright conditions, suggests that the underlying mechanism that causes the left bias is more sensitive to stimulus tilting than head tilting. This is a tentative conclusion that implies that gravitational or corporeal coordinates are more important than object centered coordinates for the occurrence of left bias.

The importance of the stimuli's alignment with gravitational or corporeal coordinates was also indicated by the results in the Subject Tilted Stimulus Tilted condition. In this condition the stimlus was aligned with retinal coordinates, however there was no significant occurrence of left bias. If the left bias was due to a direct access of the visual information then a significant bias should have occurred in the Subject Tilt Stimulus Tilt condition. A left bias in the Subject Tilt Stimulus Tilt condition was expected due to the importance of retinal orientation for certain stimuli such as faces (Rock 1973). The lack of left bias in this condition indicates that an attentional mechanism may be, at least in part, responsible for the left bias.

GENERAL CONCLUSIONS

Experiment One revealed that the occurrence of left bias was greatest when the two sides of the face were most asymmetrical. Thus open mouth smiles were more effective than closed mouth smiles for eliciting the bias. The results of Experiment Two suggested that the occurrence of left bias was more dependent on the tilt of the stimuli than the tilt of the subject.

In both studies the results obtained in the 'standard' conditions (Central VF for experiment one, Subject Upright Stimulus Upright for experiment two) revealed a great deal of variance between subjects. Handedness therefore may be only a mildly useful predictor of a persons tendency to asymmetrically perceive faces. Future subject selection might benefit from the incorporation of a measure of left bias tendency. For example performance on a line bisection task may identify those subjects that are most likely to show a left bias for faces.

The subject variance, however, may also reflect what may have been a relatively insensitive measure of left bias. Subjects were not able to pass a trial if they could not distinguish between the stimulus faces on the basis of happiness, thus significant results may have been clouded by random responding. The forced choice paradigm was used to motivate subjects to find differences between the two faces. During pre-experimental testing pilot subjects abstained from up to 80% of the judgements when the procedure permitted this. To include a "don't know" option in future experiments may yield better data, however significantly more trials would be needed to ensure that data is obtained in each experimental cell.

The failure to demonstrate a left bias in the absence of retinal factors does not force one to accept that the bias is due to retinal factors alone, but that it is dependent on the superior information available when the retinas are aligned with the face stimulus. From Experiment two there was an indication that stimulus alignment with retinal coordinates of space may not be vital for the left bias. This evidence however does not show that retinal factors are not important but that, in a condition in which retinal coordinates were aligned with the stimulus, a significant left bias did not occur.

Future researchers should refine the bi-emotional chimera task for obtaining the left bias for faces, to more sensitively detect genuine bias by including a 'pass' option for the subjects. Also, by developing a subject selection proceedure that pretests left bias susceptibility, the 'tilting' task of experimental two (in particular) could be successful in determining the source of the left bias.

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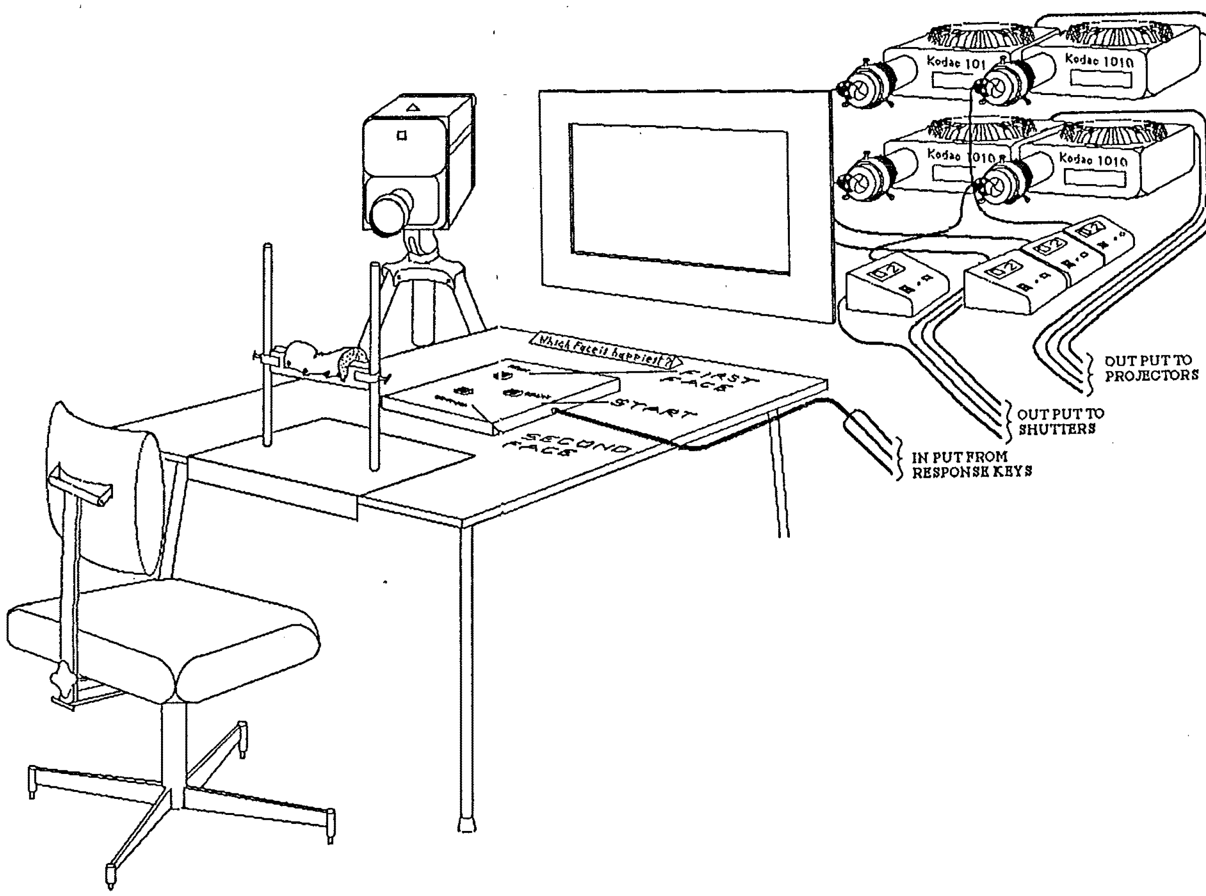
LIST OF APPENDICES



EXERIMENT ONE APPARATUS

A	B	C	D	E	F	G	H	I	J	K	L	M	N
EXPERIMENT	ONE	DATA											
						BLOCK	ONE						
COMPOSITE:	Le Hemif	Le Hemif	Ri Hem	Ri Hem	Le Hemif	Le Hemif	Ri Hem	Ri Hem	Le Hemif	Le Hemif	Ri Hem	Ri Hem	
VIS FIELD:	LVF	LVF	LVF	LVF	CVF	CVF	CVF	CVF	RVF	RVF	RVF	RVF	
SMILE TYPE:	Open	Closed	Open	Closed	Open	Closed	Open	Closed	Open	Closed	Open	Closed	
SUBJECT no:													
1a	50	100	33	0	0	100	0	0	0	50	50	33	
1b	100	100	67	33	50	50	67	100	50	50	67	33	
1c	67	50	50	50	67	67	100	50	33	33	50	100	
1d	33	33	0	50	67	0	50	50	0	0	0	0	
2a	100	0	0	67	50	50	33	100	50	100	67	67	
2b	50	0	67	67	50	0	100	0	0	100	67	67	
2c	50	67	100	100	33	33	100	0	67	0	0	0	
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3b	0	100	50	33	50	50	67	33	100	100	33	67	
3c	33	67	100	50	100	100	50	0	33	0	50	0	
3d	33	67	50	50	67	67	100	50	67	0	50	50	
4a	0	50	33	67	50	50	100	33	0	50	33	67	
4b	50	100	67	33	100	50	100	33	0	0	67	100	
4c	67	0	100	100	33	0	0	100	67	67	0	0	
4d	33	33	0	100	67	67	50	50	67	33	0	100	
5a	50	50	33	33	50	50	33	0	100	0	33	67	
5b	50	50	33	0	0	0	33	33	50	50	33	33	
5c	33	0	100	0	67	33	100	50	33	67	0	50	
5d	67	67	0	100	67	33	50	100	100	0	100	0	
6a	0	100	100	50	50	50	33	67	100	50	33	0	
6b	0	50	67	67	0	50	67	33	50	50	67	33	
6c	33	100	100	0	33	67	50	50	100	67	100	50	
6d	67	0	0	100	67	33	100	0	50	50	0	50	
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7b	100	50	50	100	67	0	0	67	50	50	100	0	
7c	67	67	50	50	33	67	100	50	100	33	50	100	
7d	0	33	50	50	50	33	100	0	33	33	100	50	
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8b	50	50	0	67	67	0	33	67	50	50	67	67	
8c	50	33	0	0	100	33	100	50	50	67	50	50	
8d	67	0	100	0	50	33	50	50	67	33	0	50	
9a	50	50	0	100	50	0	0	67	100	0	67	33	
9b	50	50	33	33	0	50	67	100	52.13	0	33	50	
9c	50	100	0	50	33	0	100	50	50	100	100	50	
9d	67	100	0	0	100	100	0	100	100	67	50	50	
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10c	50	67	0	50	67	67	50	50	67	100	50	50	
10d	33	33	100	0	67	33	50	50	50	0	0	50	
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11b	50	0	100	50	50	100	67	0	100	50	50	67	
11c	33	0	50	100	67	67	0	100	33	0	0	50	
11d	33	0	50	0	67	100	100	100	33	67	100	100	
12a	0	50	67	50	50	50	67	33	0	0	67	67	
12b	50	50	33	67	100	50	67	67	50	50	67	100	
12c	33	50	100	100	67	0	50	0	0	33	100	100	
12d	33	67	0	0	67	67	0	100	67	33	100	0	
EXPERIMENT	ONE	DATA											
						BLOCK	ONE						
COMPOSITE:	Le Hemif	Le Hemif	Ri Hem	Ri Hem	Le Hemif	Le Hemif	Ri Hem	Ri Hem	Le Hemif	Le Hemif	Ri Hem	Ri Hem	
VIS FIELD:	LVF	LVF	LVF	LVF	CVF	CVF	CVF	CVF	RVF	RVF	RVF	RVF	
SMILE TYPE:	Open	Closed	Open	Closed	Open	Closed	Open	Closed	Open	Closed	Open	Closed	
MEAN	45.104	46.188	46.521	45.833	52.146	44.438	58.354	48.958	52.128	44.083	50.375	46.896	
SD	26.028	35.147	37.545	35.193	28.564	32.918	35.276	34.67	33.844	32.573	33.484	32.437	
std error	3.2535	4.3934	4.6932	4.3992	3.5705	4.1147	4.4094	4.3337	4.2304	4.0716	4.1855	4.0546	
		Block 1 =			48.419								
		SD			33.199								
		OVER ALL =			50.417								
		SD =			33.137								
for Block 1,2													
graph:	LVF MEAI	45.911		CVFMEAN	50.974		RVFMEAN	48.37					
	SD	33.505		SD	33.094		SD	32.976					
	STDERRC	4.1882		STDERRC	4.1367		STDERRC	4.1221					

A	B	C	D	E	F	G	H	I	J	K	L	M	N
									BLOCK	TWO			
COMPOSITE:	Le Hem	Le Hem	Ri Hem	Ri Hem	Le Hem	Le Hem	Ri Hem	Ri Hem	Le Hem	Le Hem	Ri Hem	Ri Hem	
VIS FIELD:	LVF	LVF	LVF	LVF	CVF	CVF	CVF	CVF	RVF	RVF	RVF	RVF	
SMILE TYPE:	Open	Closed	Open	Closed	Open	Closed	Open	Closed	Open	Closed	Open	Closed	
SUBJECT no:													
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1b	0	100	0	100	67	33	100	100	33	33	50	100	
1c	50	0	67	67	0	100	33	67	50	50	33	33	
1d	50	50	33	0	0	100	67	67	50	50	33	67	
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2b	67	33	50	0	67	67	50	100	67	67	100	50	
2c	0	0	0	33	100	50	33	0	0	100	100	33	
2d	100	100	100	67	50	50	67	33	0	50	33	33	
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3b	33	33	100	100	100	33	50	50	33	33	50	100	
3c	50	0	33	0	100	0	67	33	0	0	33	33	
3d	100	50	67	33	50	50	100	0	100	50	33	33	
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4b	100	33	50	50	33	100	50	50	67	67	0	0	
4c	0	100	33	100	100	0	33	0	0	50	67	100	
4d	100	100	67	67	100	0	33	67	50	50	67	33	
5a	0	33	0	100	33	33	100	50	100	0	50	0	
5b	33	0	50	100	33	33	0	0	33	100	0	0	
5c	100	100	67	67	50	50	33	33	50	0	50	100	
5d	100	50	33	67	50	50	0	33	50	50	33	67	
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6b	67	67	100	50	33	100	50	100	33	67	0	100	
6c	100	0	50	67	100	100	67	67	100	0	67	50	
6d	0	100	50	33	100	50	33	50	100	50	67	67	
7a	100	33	100	0	67	33	50	50	100	100	100	100	
7b	67	10	50	50	0	33	0	100	33	33	50	50	
7c	0	100	100	50	50	50	100	33	50	50	100	67	
7d	100	0	0	100	0	0	33	0	100	50	100	33	
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8b	33	0	50	0	33	67	100	100	67	67	100	50	
8c	50	50	50	67	0	50	0	33	50	50	67	67	
8d	0	0	100	67	100	50	100	67	100	100	67	100	
9a	33	33	0	100	67	33	50	50	33	67	50	50	
9b	67	33	0	50	67	33	50	50	33	0	50	50	
9c	0	50	67	100	50	50	67	33	0	0	67	67	
9d	50	0	33	0	50	50	33	67	50	50	67	33	
10a	33	33	50	50	67	33	50	50	100	67	50	100	
10b	67	33	0	100	100	33	100	50	100	33	50	50	
10c	100	0	0	0	100	50	67	67	50	100	100	33	
10d	0	0	33	0	50	100	67	50	50	50	50	100	
11a	33	33	100	100	33	67	0	50	0	100	0	100	
11b	67	33	100	100	33	67	50	50	67	0	50	100	
11c	50	100	67	100	50	0	100	33	50	50	67	33	
11d	100	100	67	33	100	0	0	33	100	100	33	50	
12a	33	67	100	50	33	100	100	100	33	67	50	0	
12b	0	67	50	100	67	67	0	50	67	33	50	0	
12c	0	50	67	33	50	50	33	0	50	50	50	50	
12d	100	50	67	33	100	100	67	100	0	50	0	67	
MEAN	50.333	45.271	51.063	54.875	58.313	51.708	54.854	50.333	51.375	52.813	52.851	55.188	
SD	39.015	35.86	33.984	36.584	32.51	30.296	33.032	29.936	34.063	29.905	28.895	32.164	
std error	4.8768	4.4825	4.248	4.573	4.0638	3.787	4.129	3.742	4.2579	3.7382	3.6119	4.0204	
			PART 2 =	52.415									
			SD	32.981									
		LVFMEAN	50.385		CVFMEAN	53.802		RVFMEAN	53.057				
		SD	36.281		SD	31.376		SD	31.104				
		STDERRC	4.5351		STDERRC	3.922		STDERRC	3.888				

ANOVA SUMMARY TABLE EXPERIMENT ONE

SOURCE OF VARIATION	DEGREES OF FREEDOM	F VALUES	P
B	1,47	4.597	.037
H	1,47	1.144	.290
BH	1,47	0.022	.883
V	2,47	1.541	.220
BV	2,94	0.83	.920
HV	2,94	0.088	.916
BHV	2,94	0.862	.426
S	1,94	2.960	.092
BS	1,47	0.850	.361
HS	1,47	0.297	.589
BHS	1,47	0.186	.668
VS	2,47	1.059	.351
BVS	2,94	0.173	.762
HVS	2,94	0.071	.931
BHVS	2,94	0.357	.701

B = Experimental Blocks
H = Hemiface that the half smile came from
V = Visual field the trials were displayed in
S = Smile type used in the chimera

ANOVA SUMMARY TABLE: EXPERIMENT ONE BLOCK TWO DATA

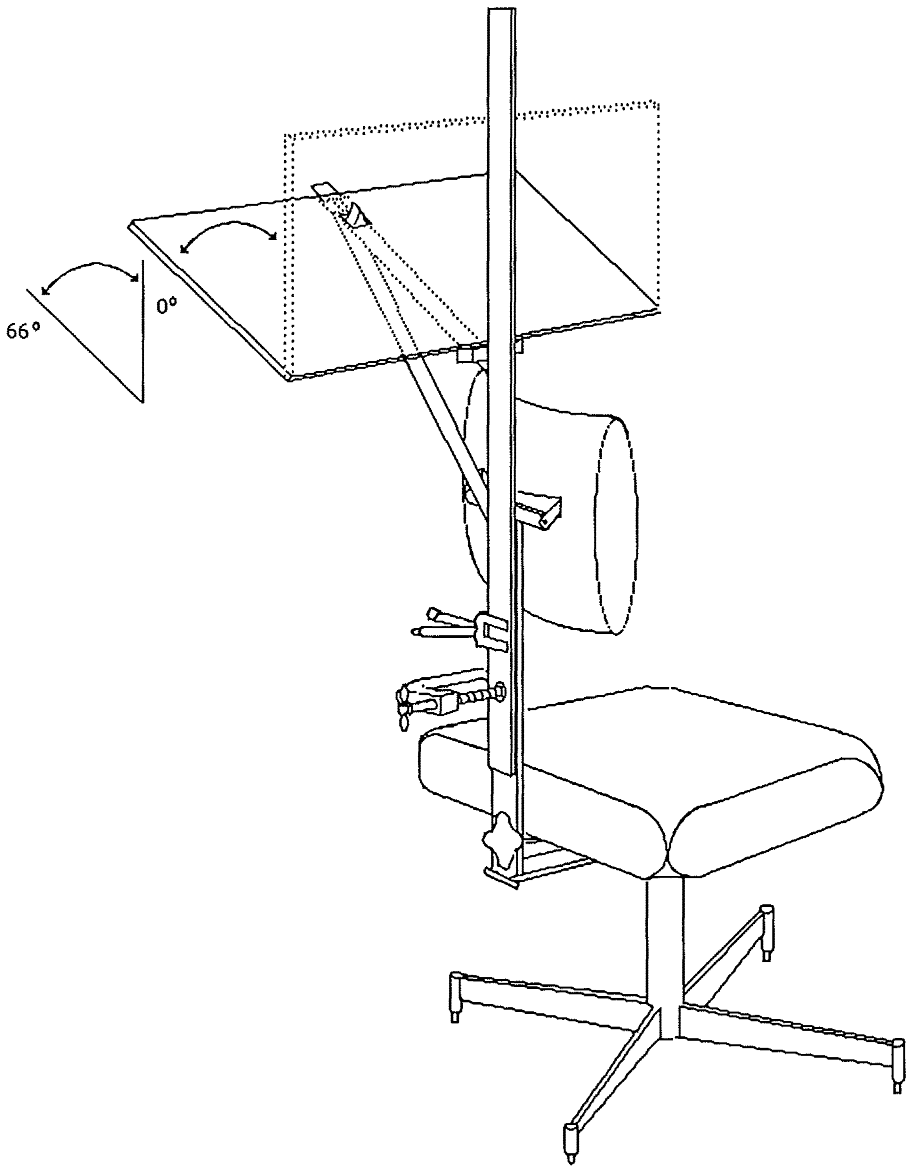
SOURCE OF VARIATION	DEGREES OF FREEDOM	F VALUES	P
H	1,47	.368	.547
V	2,47	.462	.631
HV	2,94	.798	.453
S	1,94	.280	.600
HS	1,47	.583	.450
VS	2,47	.495	.611
HVS	2,94	.267	.766

H = Hemiface that the half smile came from
V = Visual field the trials were displayed in
S = Smile type used in the chimera

ANOVA SUMMARY TABLE: EXPERIMENT ONE CENTRAL VISUAL FIELD DATA

SOURCE OF VARIATION	DEGREES OF FREEDOM	F VALUES	P
B	1,47	.742	.39
H	1,47	.244	.62
BH	1,47	1.790	.19
S	1,47	4.576	.04
BS	1,47	.145	.71
HS	1,47	.001	.98
BHS	1,47	.107	.74

B = Experimental Block (1 = block one, 2 = block two)
H = Hemiface that the half smile came from (1 = left hemiface, 2 = right hemiface)
S = Smile type used in the chimera (1 = open, 2 = closed)



EXPERIMENT TWO TILT CHAIR

	A	B	C	D	E
1	EXPERIMENT	TWO DATA			
2	Subjects	head	stimulus	RIGHT HMFC	LEFT HMFC
3	1	1	1	0.25	0.5
4	2	1	1	0.375	0.375
5	3	1	1	-0.5	0.125
6	4	1	1	-0.625	-0.25
7	5	1	1	0.25	0.625
8	6	1	1	0.75	0.5
9	7	1	1	0	-0.25
10	8	1	1	0.125	0
11	9	1	1	0.25	-0.125
12	10	1	1	-0.375	0
13	11	1	1	0.75	0.875
14	12	1	1	0.75	1
15	13	1	1	0.5	0.5
16	14	1	1	0.625	0.75
17	15	1	1	-0.75	-0.875
18	16	1	1	0.75	0.875
19	17	1	2	-0.5	0
20	18	1	2	0.5	0.5
21	19	1	2	0.375	0.75
22	20	1	2	0.375	-0.25
23	21	1	2	0.75	0.375
24	22	1	2	-0.125	0
25	23	1	2	0.875	0.875
26	24	1	2	0	0.25
27	25	1	2	0.25	0.625
28	26	1	2	0.125	0.25
29	27	1	2	-0.375	-0.25
30	28	1	2	0	-0.25
31	29	1	2	-0.125	-0.875
32	30	1	2	-0.25	-0.25
33	31	1	2	0.125	-0.125
34	32	1	2	0.375	-0.125
35	33	2	1	-0.25	0.125
36	34	2	1	-0.25	0
37	35	2	1	0.625	0.875
38	36	2	1	-0.125	0.25
39	37	2	1	-0.625	-0.5
40	38	2	1	0.125	0.625
41	39	2	1	-0.125	0.125
42	40	2	1	-0.25	-0.5
43	41	2	1	-0.875	-0.5
44	42	2	1	0.25	0.25
45	43	2	1	0	-0.125
46	44	2	1	0.75	0.625
47	45	2	1	0.625	0.375
48	46	2	1	0.75	0.5
49	47	2	1	-0.5	0
50	48	2	1	0.125	0.5
51	49	2	2	-0.125	0.125
52	50	2	2	0.5	0.25
53	51	2	2	-0.125	0
54	52	2	2	0.875	0.625
55	53	2	2	0.5	0.75
56	54	2	2	-0.625	-0.75
57	55	2	2	0.75	0.75
58	56	2	2	0.375	0.875
59	57	2	2	-0.25	-0.125
60	58	2	2	-0.625	-0.5
61	59	2	2	0.25	0.5
62	60	2	2	-0.25	-0.375
63	61	2	2	0.125	0
64	62	2	2	0.625	0.625
65	63	2	2	0.5	0
66	64	2	2	0.5	0.125
67					
68	mean			0.13671875	0.18164063
69	sd			0.46222308	0.46394278

ANOVA SUMMARY TABLE EXPERIMENT TWO

SOURCE OF VARIATION	DEGREES OF FREEDOM	F VALUES	P
O	1,60	.164	.69
F	1,60	.015	.90
OF	1,60	.935	.34
H	1,60	1.440	.23
OH	1,60	.460	.50
FH	1,60	4.141	.05
OFH	1,60	.003	.96

O = Subject Orientation
F = Face Chimeras orientation
H = Hemiface that the smile came from

Experiment Two Table of Means

Variable:			Mean Bias Score	
O 1			.1816	
O 2			.1367	
F 1			.1660	
F 2			.1523	
O 1	F 1			.2422
O 1	F 2			.1211
O 2	F1			.0898
O 2	F 2			.1836
H 1			.1367	
H 2			.1816	
O 1	H 1		.1719	
O 1	H 2		.1914	
O 2	H 1		.1016	
O 2	H 2		.1719	
F 1	H 1		.1055	
F 1	H 2		.2266	
F 2	H 1		.1680	
F 2	H 2		.1367	
O.1	F 1	H 1	.1953	
O 1	F 1	H 2	.2891	
O 1	F 2	H 1	.1484	
O 1	F 2	H 2	.0938	
O 2	F 1	H 1	.0156	
O 2	F 1	H 2	.1641	
O 2	F 2	H 1	.1875	
O 2	F 2	H 2	.1797	

Experiment two: T Test for each experimental cell Comparisons with chance level.

$$t\ (df) = \frac{X - U}{SD\sqrt{n}}$$

Subject upright stimulus upright

$$t\ (15) = \frac{0.242 - 0}{0.491\sqrt{16}} = 1.95,\ P<0.05$$

Subject upright stimulus tilted

$$t\ (15) = \frac{0.125 - 0}{0.397\sqrt{16}} = 1.1,\ n.s.$$

Subject tilted stimulus upright

$$t\ (15) = \frac{0.898 - 0}{0.437\sqrt{16}} = 0.8,\ n.s.$$

Subject tilted stimulus tilted

$$t\ (15) = \frac{0.184 - 0}{0.480\sqrt{16}} = 1.53,\ n.s.$$

Binomial Probabilities

$$P(X) = \frac{N!}{R!\,(N-R)!} P^{x} q^{n-x}$$

P (22) =	$\frac{32!}{22!\,10!} \times 0.5^{22} \times 0.5^{10}$	= 0.01502
P (23) =	$\frac{32!}{23!\,9!} \times 0.5^{23} \times 0.5^{9}$	= 0.00653
P (24) =	$\frac{32!}{24!\,8!} \times 0.5^{24} \times 0.5^{8}$	= 0.00244
P (25) =	$\frac{32}{25!\,7!} \times 0.5^{25} \times 0.5^{7}$	= 0.00078
P (26) =	$\frac{32!}{26!\,6!} \times 0.5^{26} \times 0.5^{6}$	= 0.00021
P (27) =	$\frac{32}{27!\,5!} \times 0.5^{27} \times 0.5^{5}$	= 0.00004
		0.02503

Therefore P(X > or = 22) < 0.05

EXPERIMENT TWO CHI ^{2} ANALYSIS

$$\text{Chi}^2 = \frac{(\text{Observed} - \text{Expected})^2}{\text{Expected}}$$

left bias in sub. up stim up + L.B.in sub up stim tilt+ L.B. in sub tilt stim up+L.B in sub tilt stim. tilt.

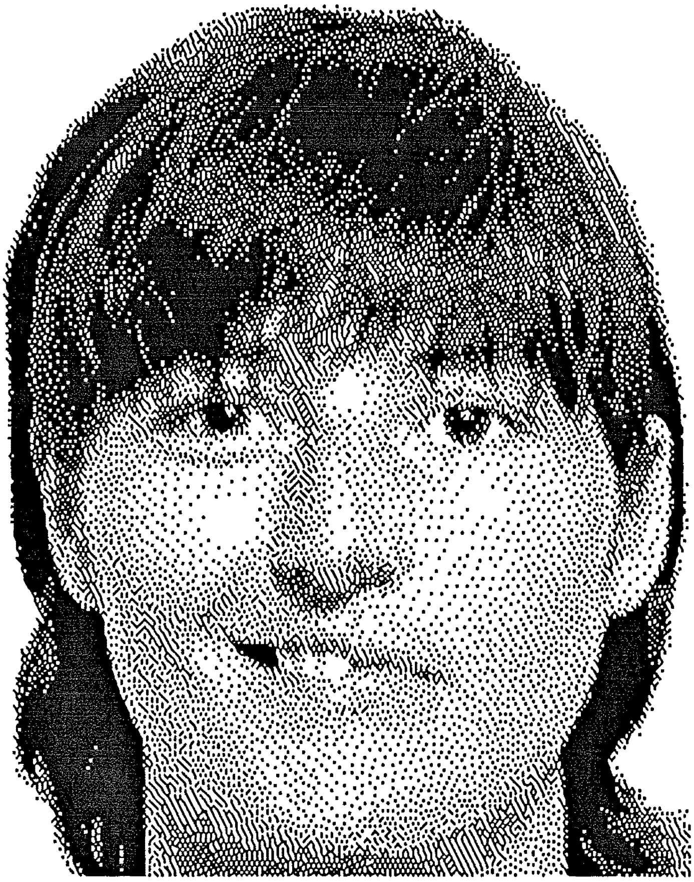
$$= \frac{(8-5)^2}{5} + \frac{(5-3)^2}{5} + \frac{(5-3.5)^2}{3.5} + \frac{(7-4.5)^2}{4.5}$$

$= 5.13$

$5.13 < 6$, therefore not significant.

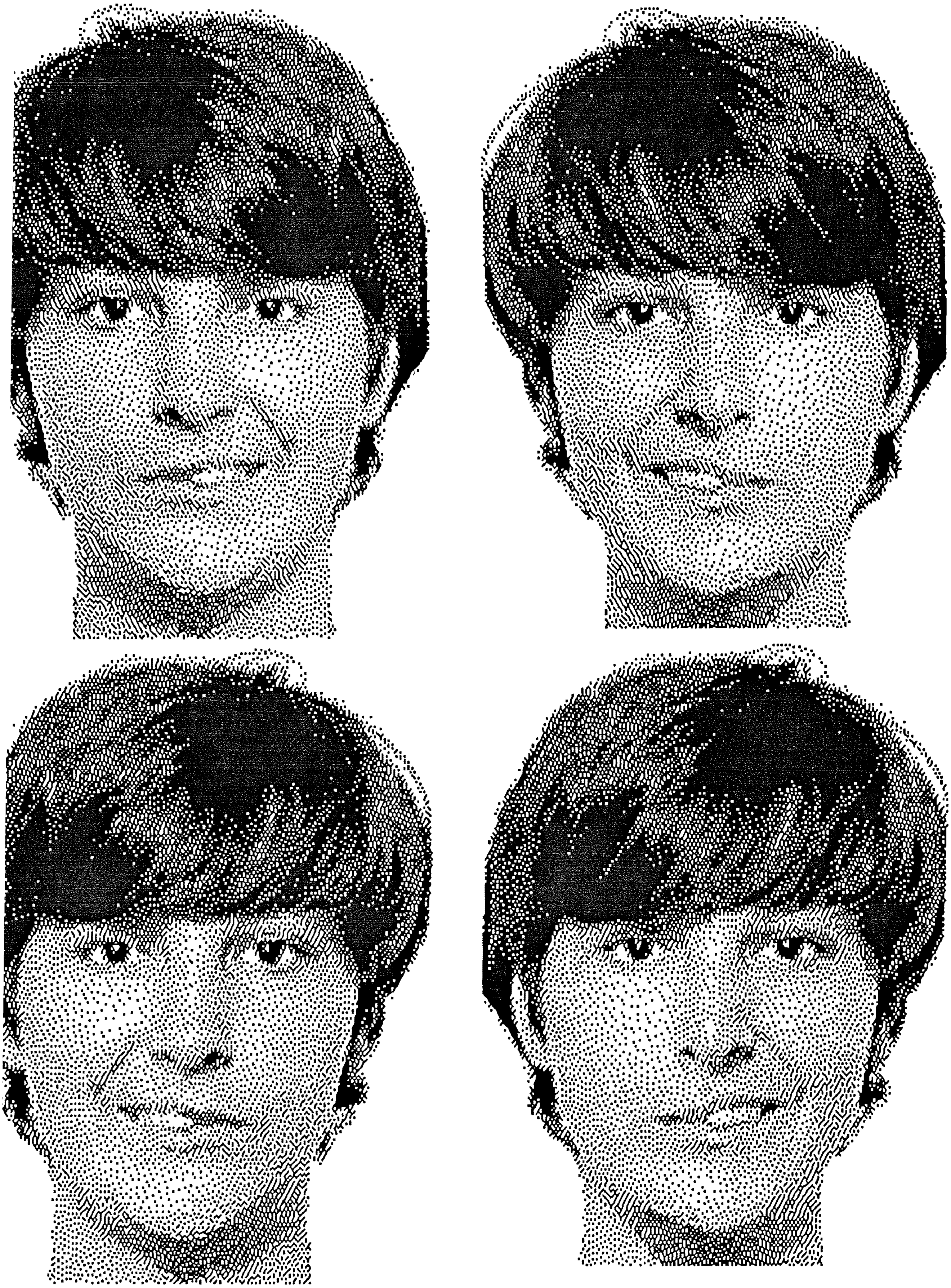
Experimental Stimuli.

The following examples of bi emotional chimera are arranged so that the original orientation composites are in the top half of the page and the corresponding mirror reversals are directly beneath.

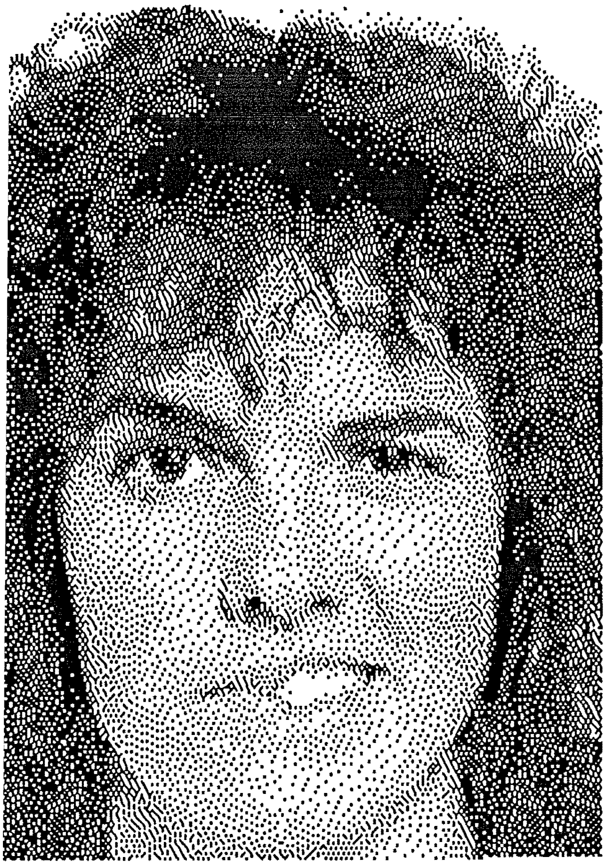


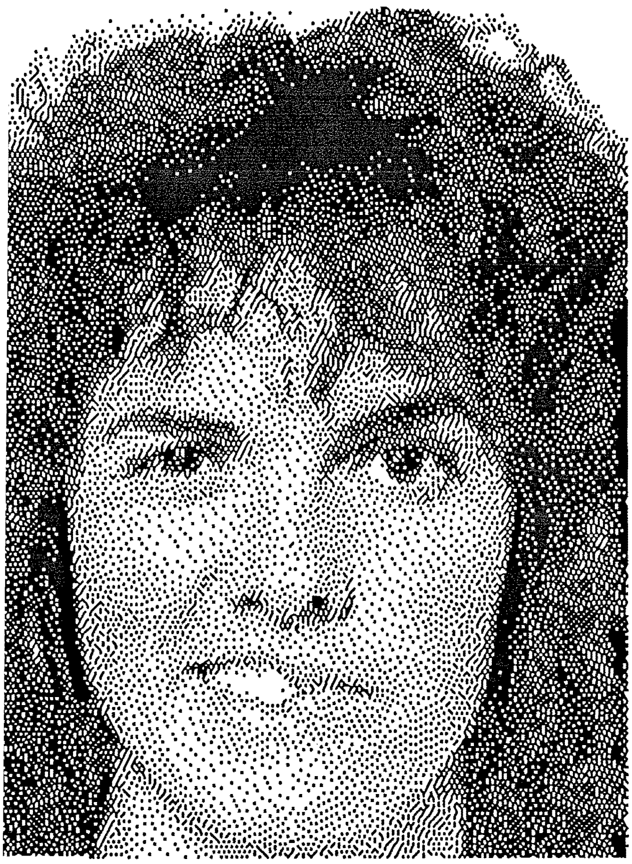
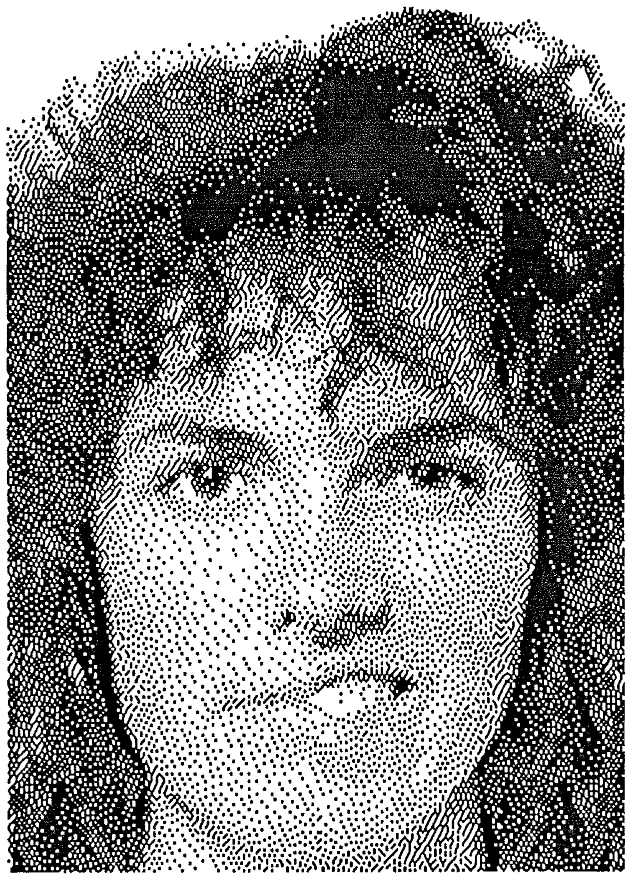

R
L

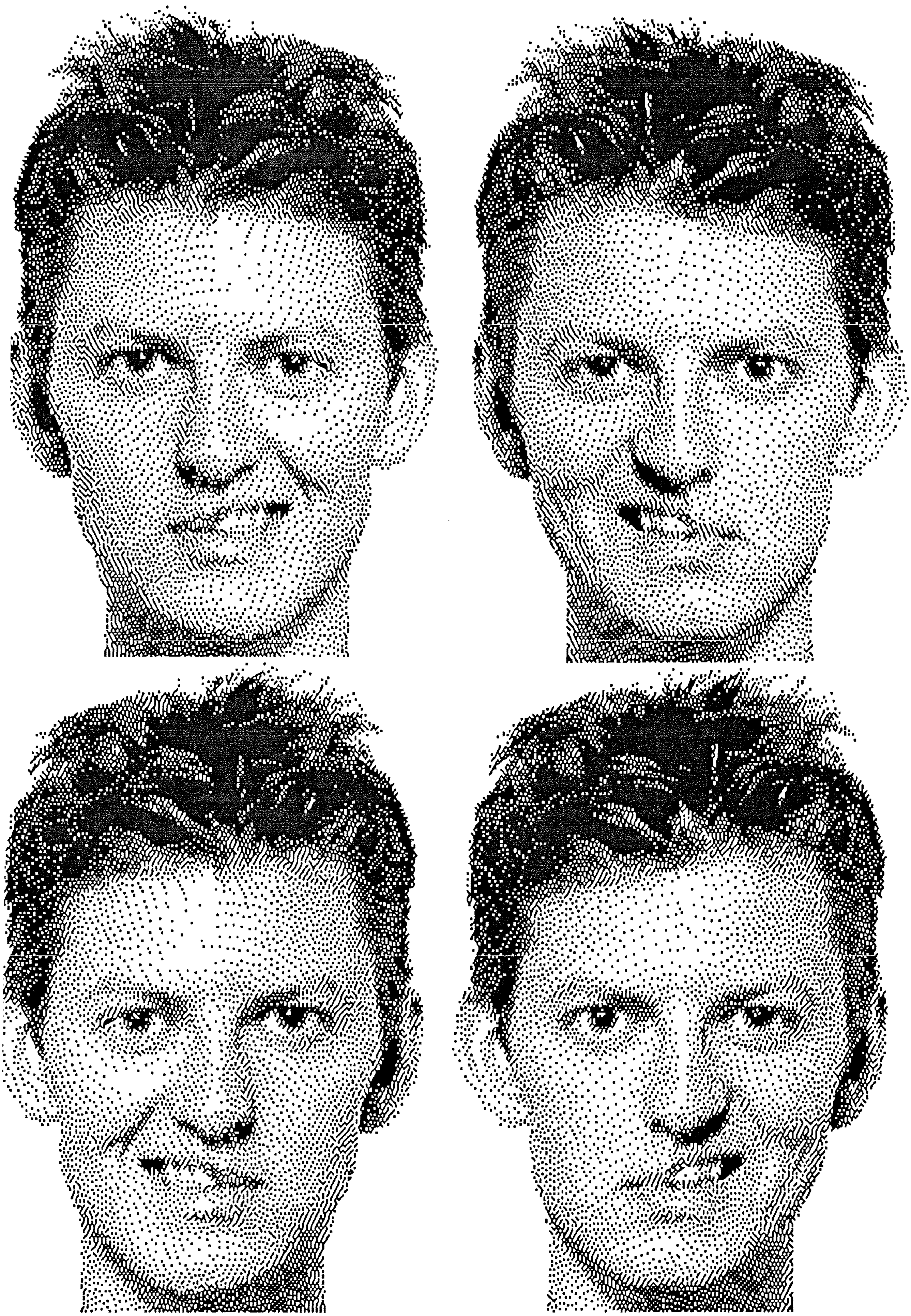

R
L



R L R L

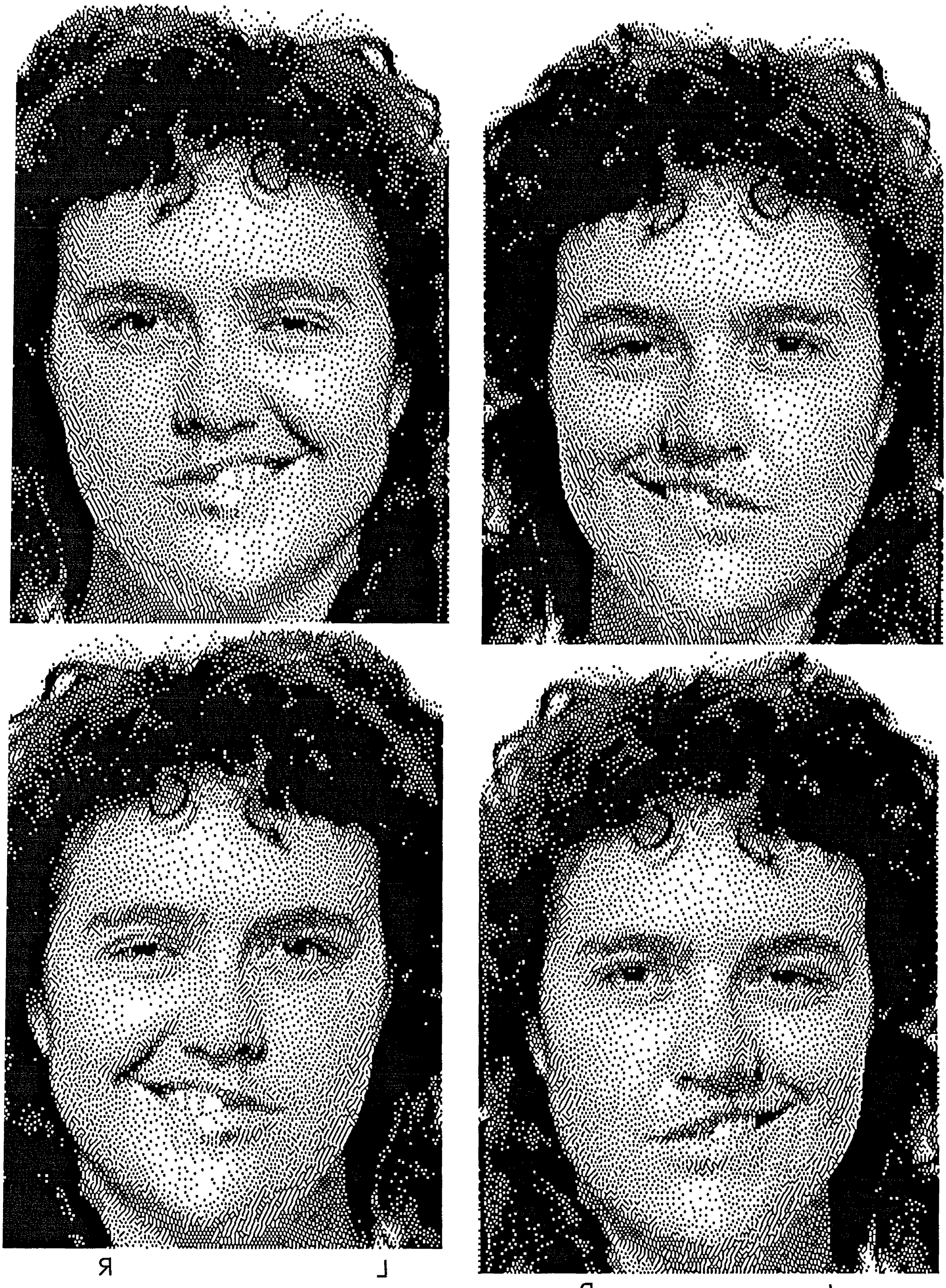


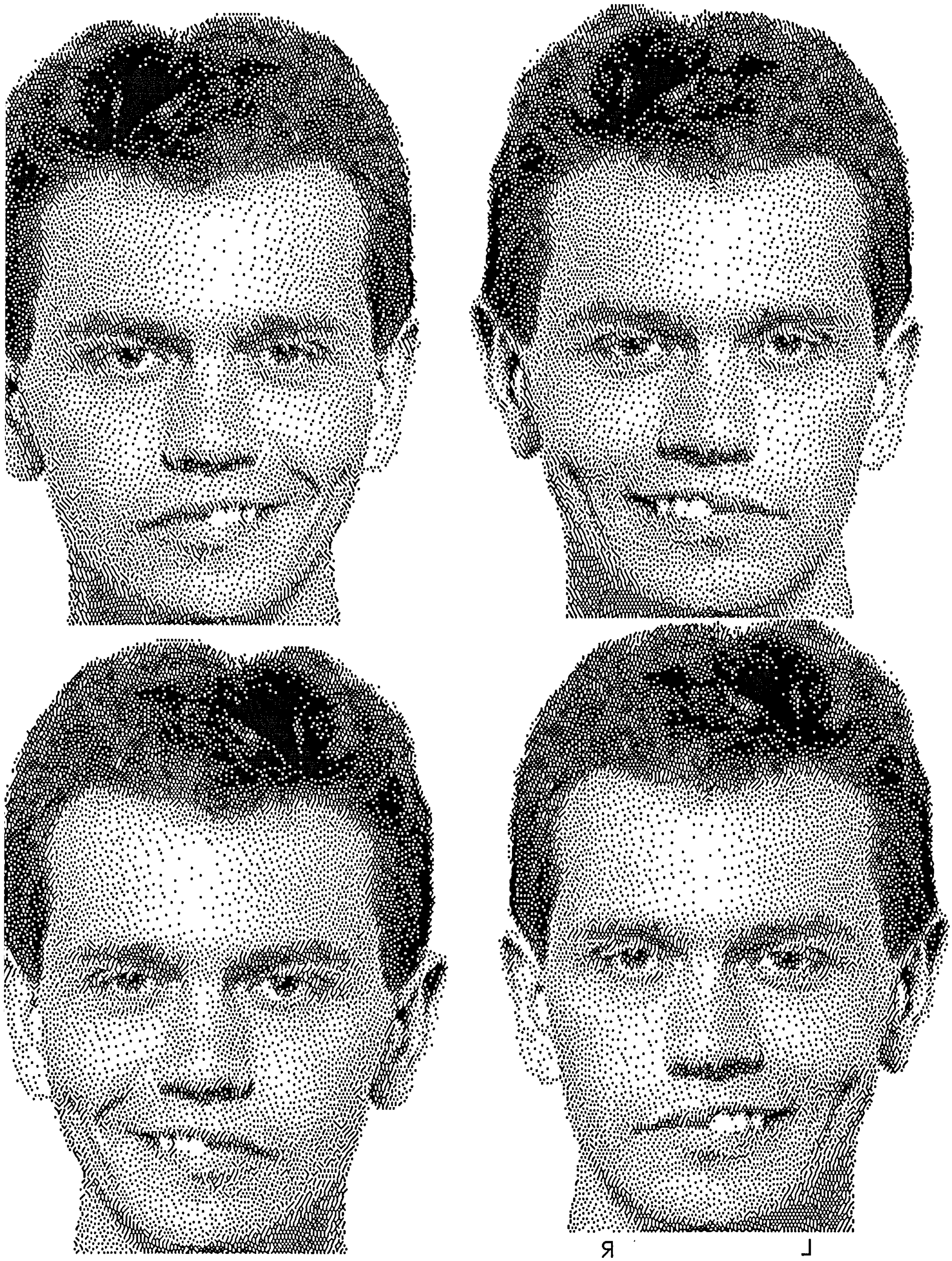


R L

R L

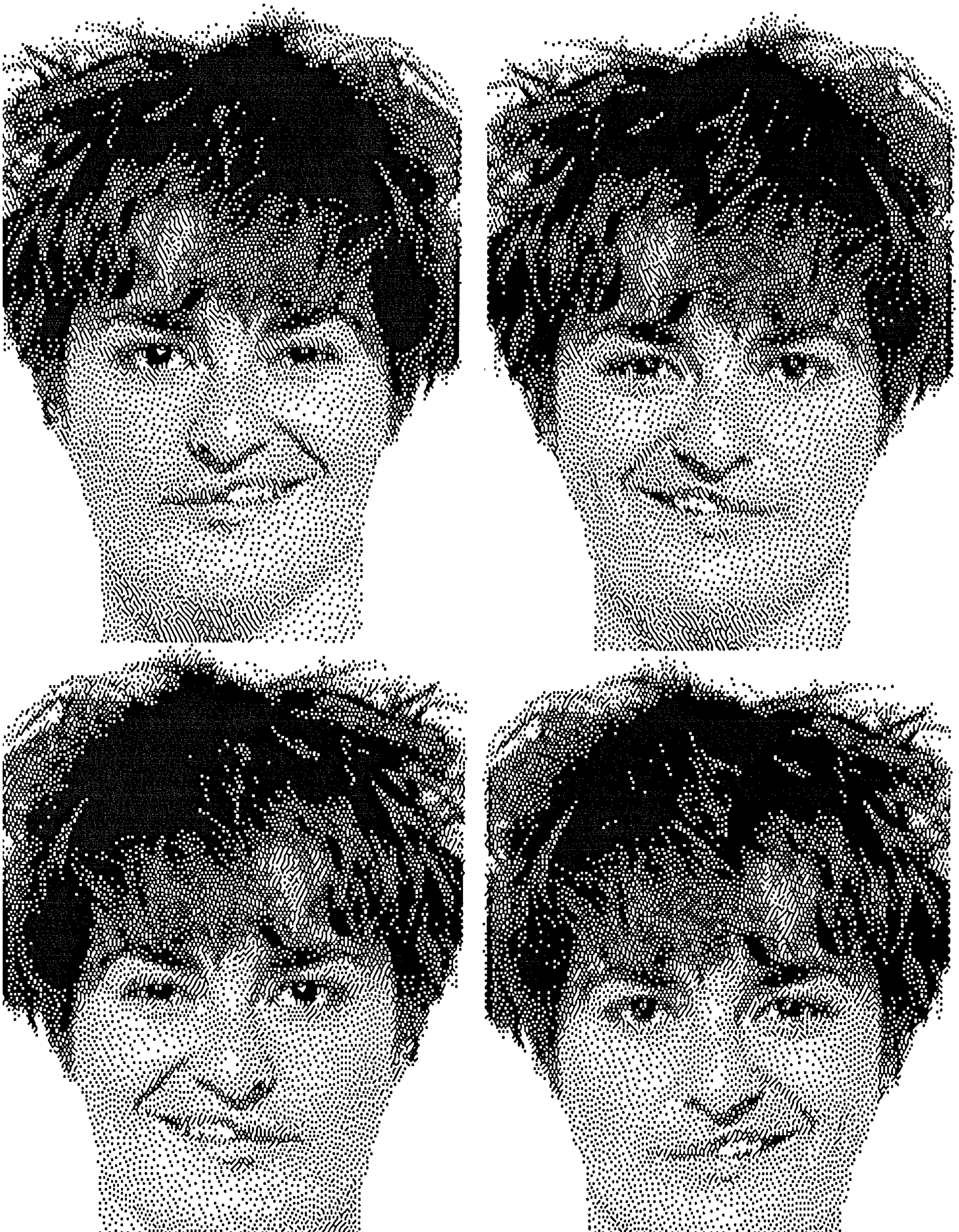


R L R L



R I

R L



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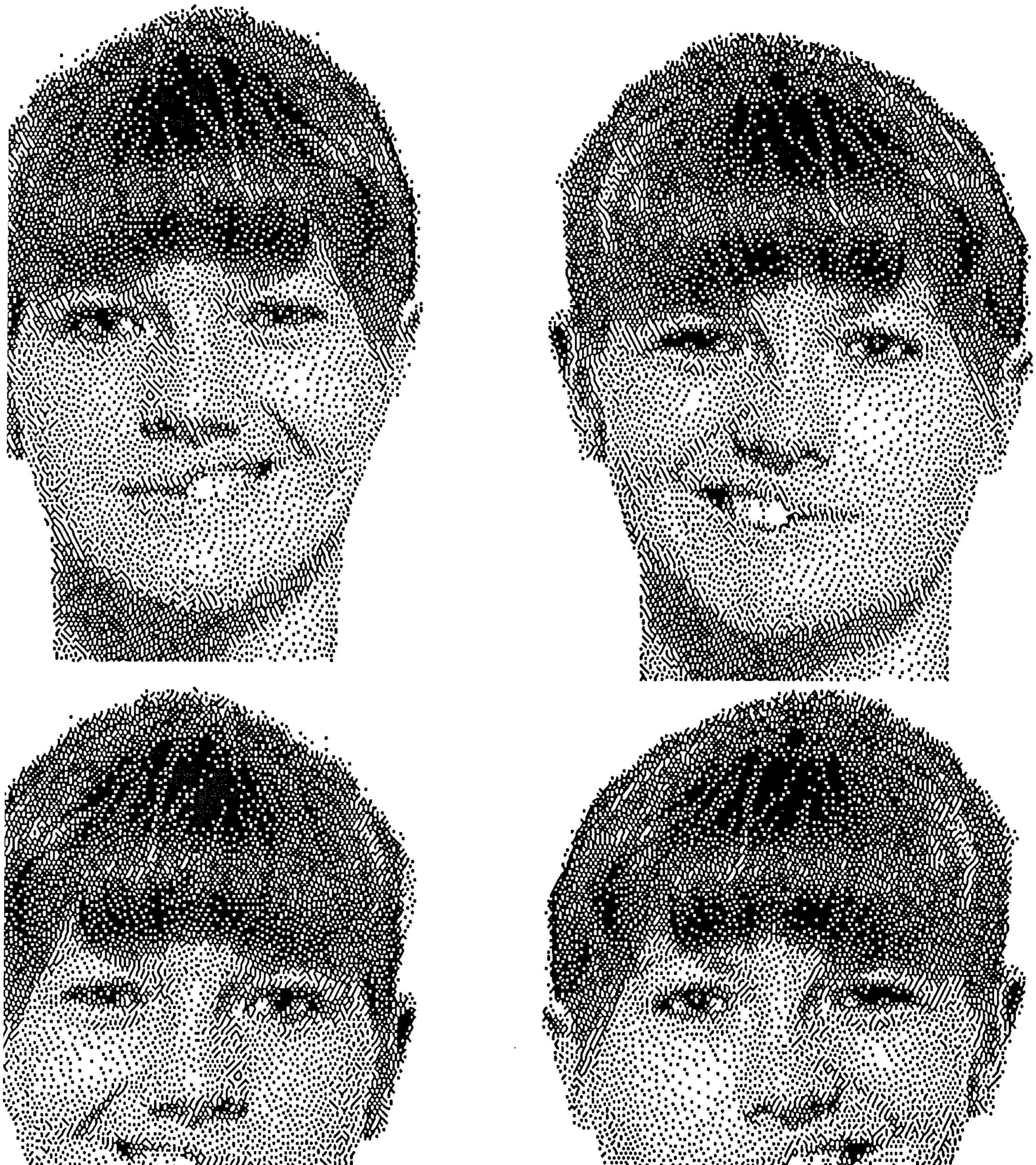

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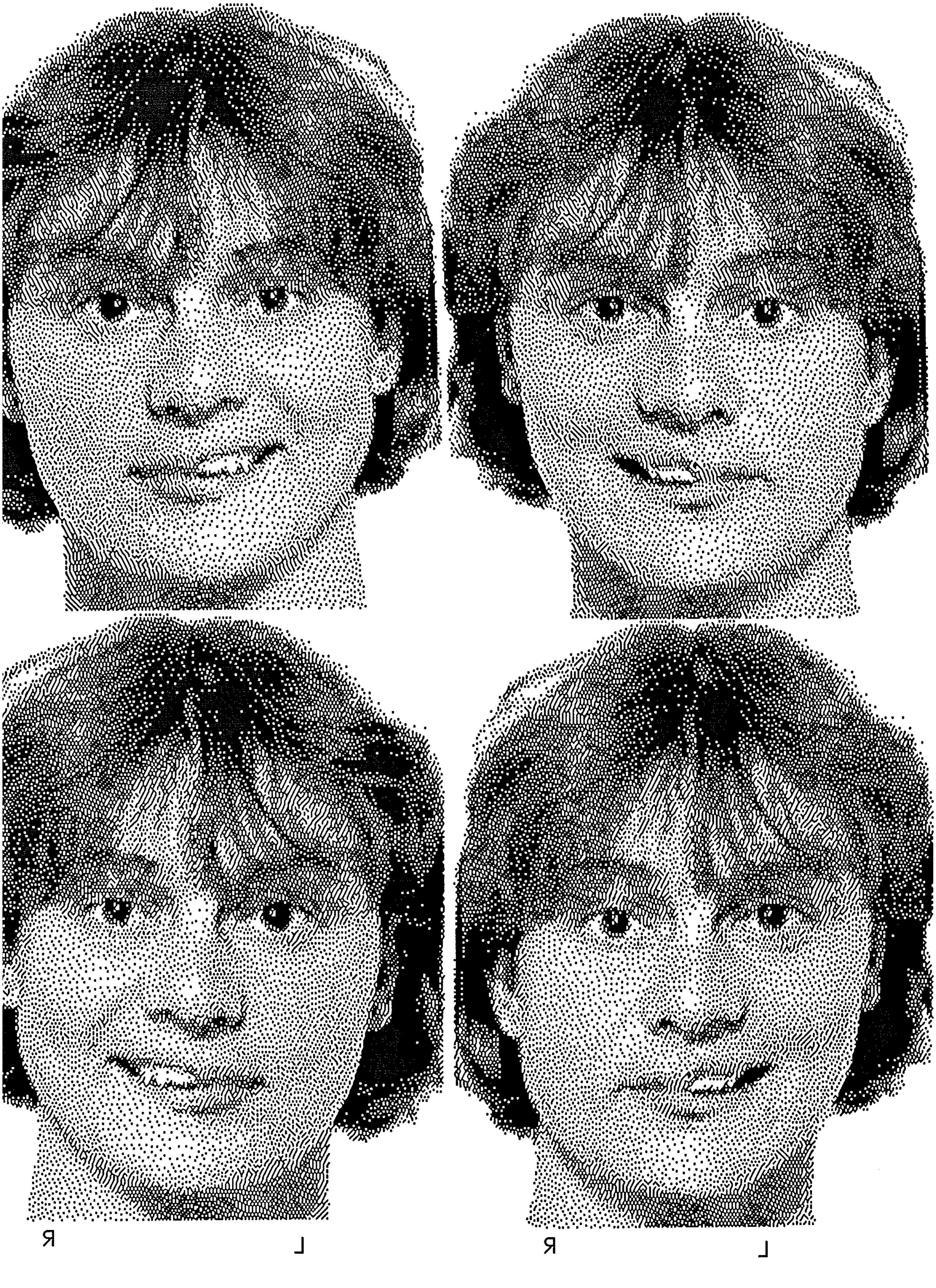

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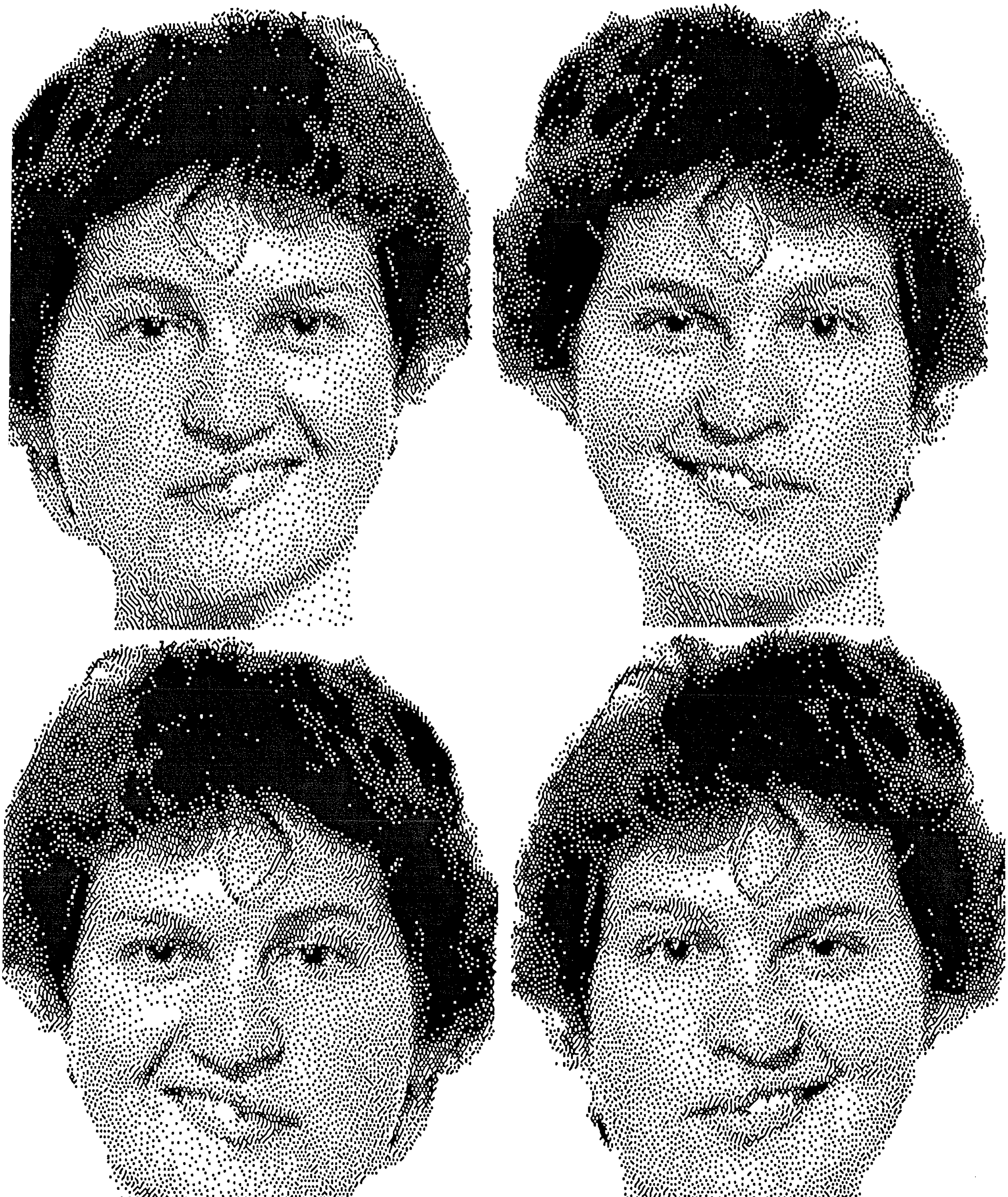

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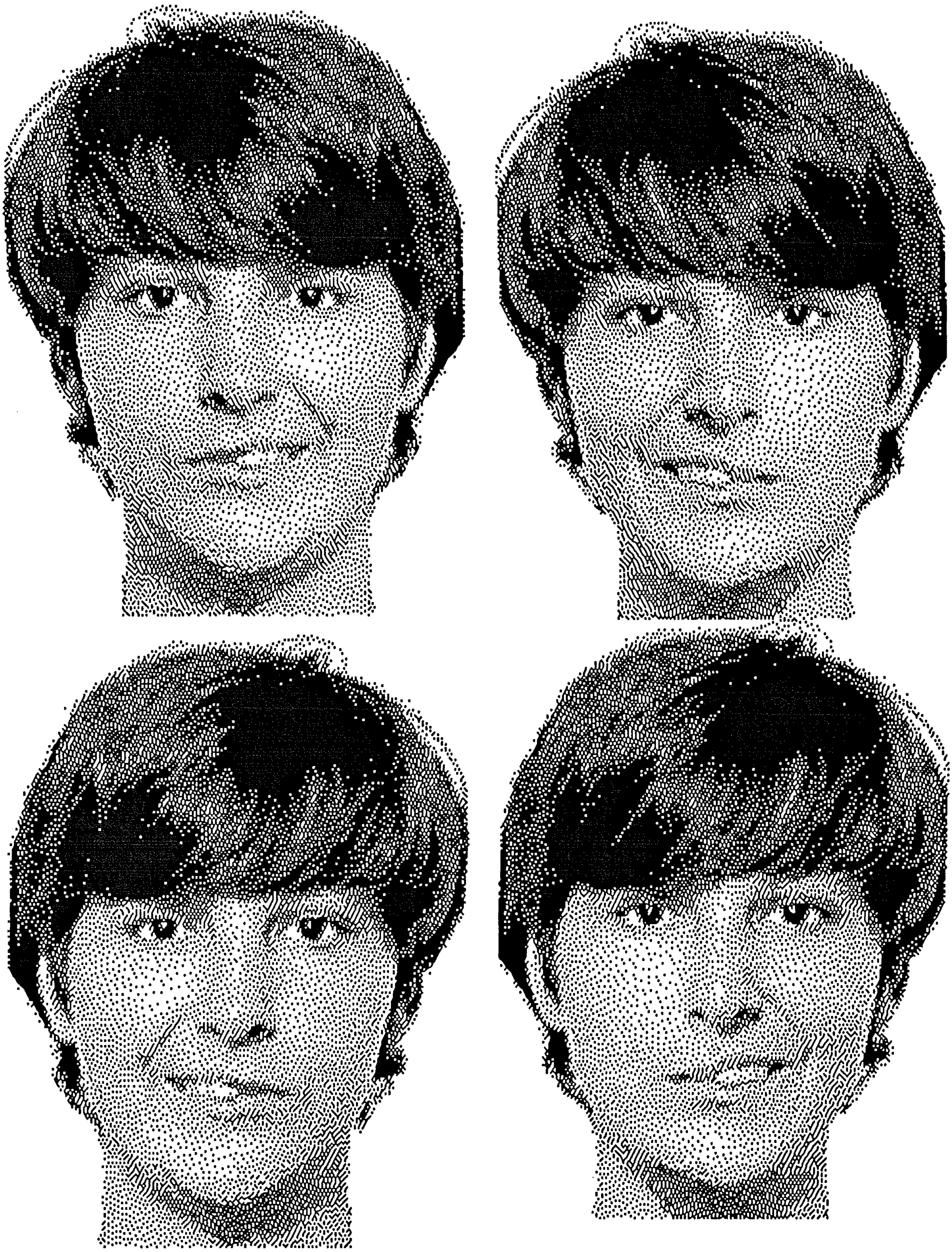

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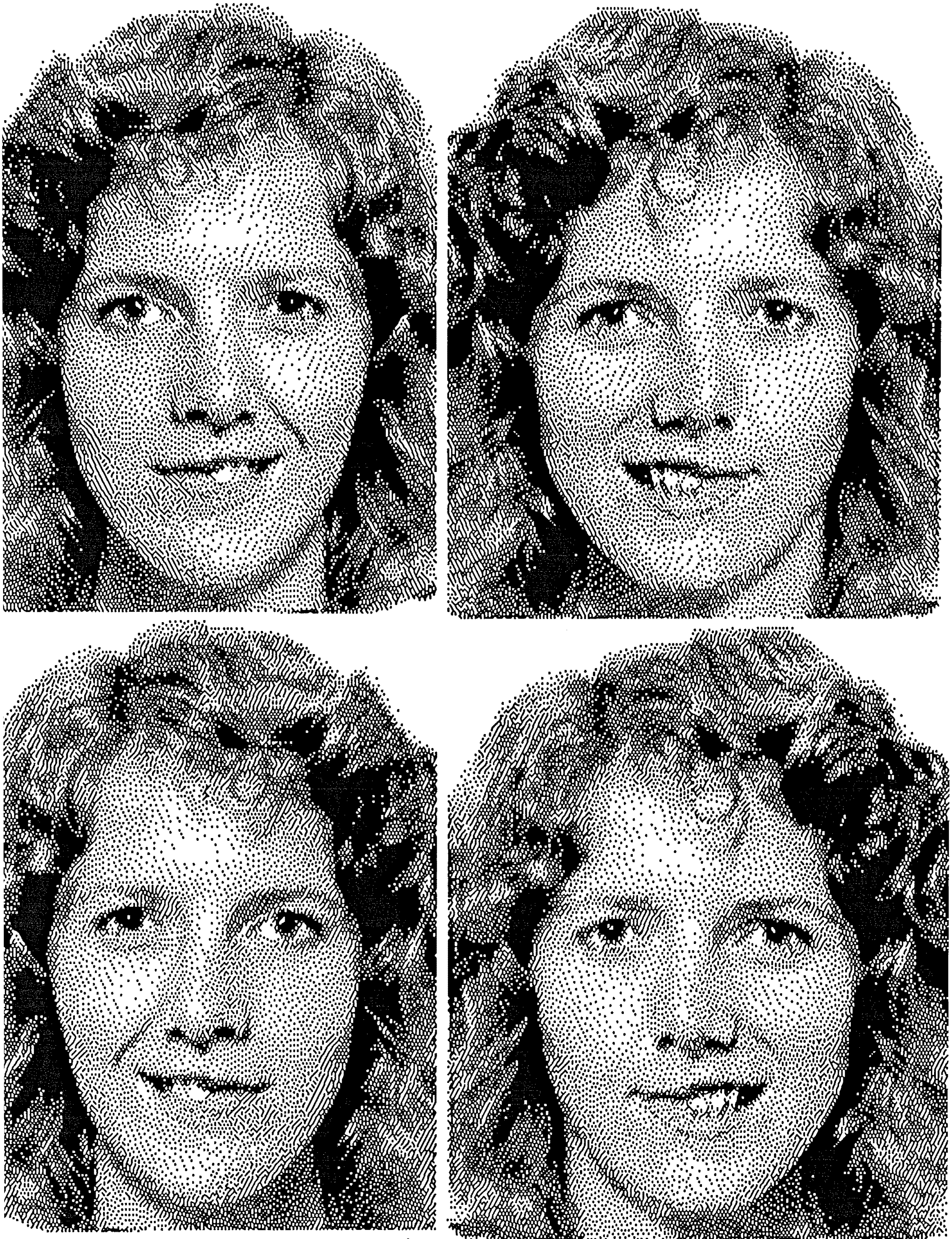
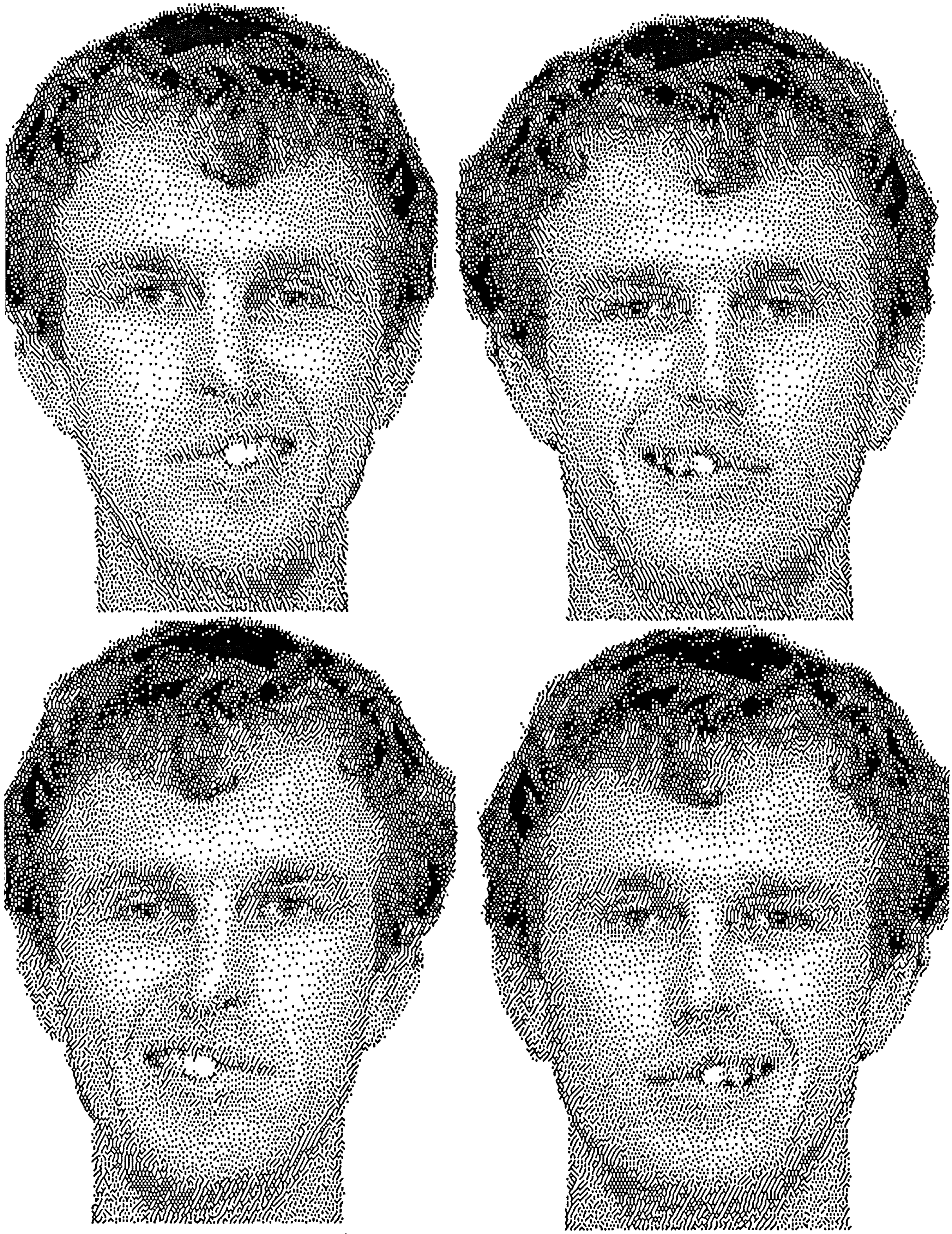
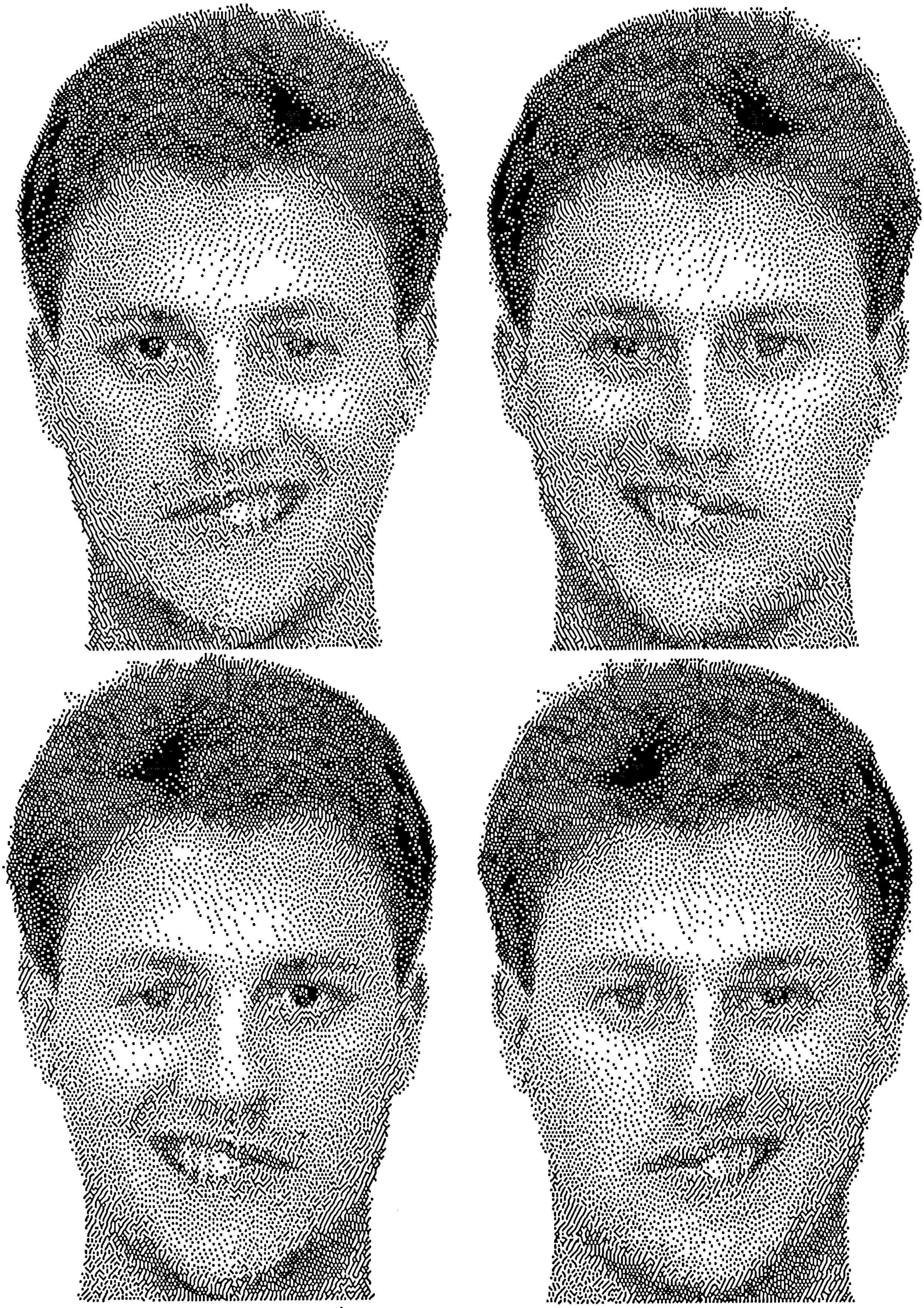



R
L
R
L



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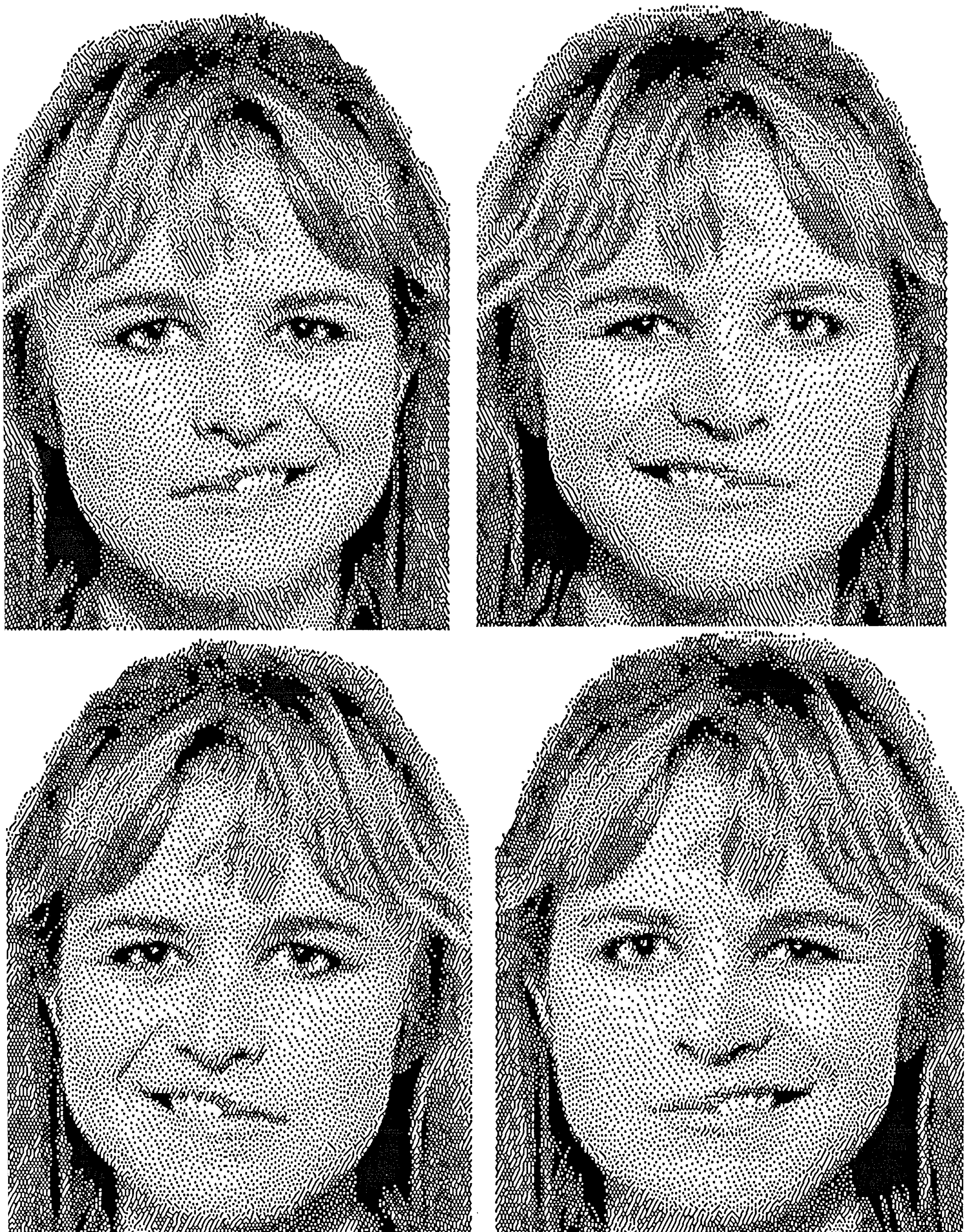
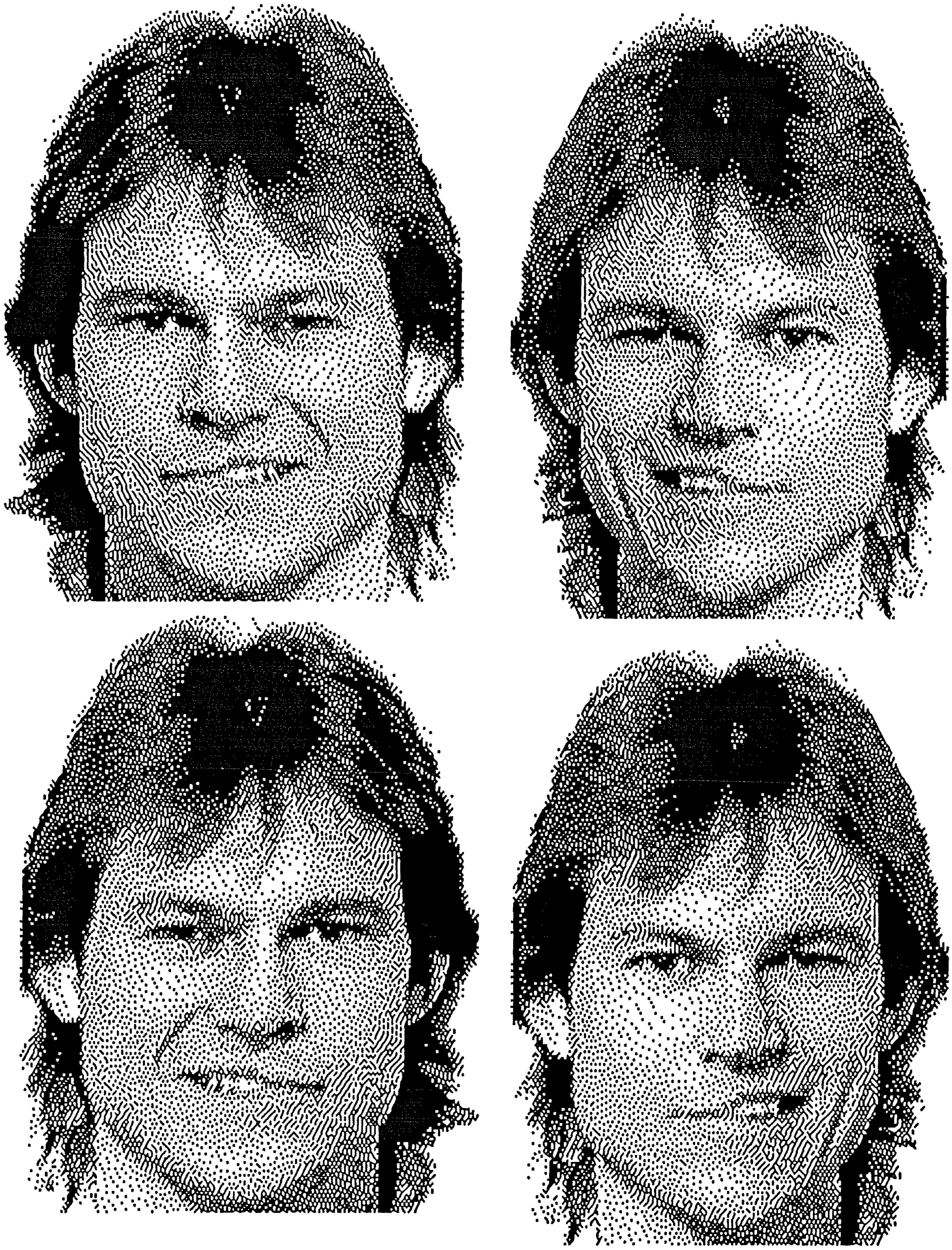
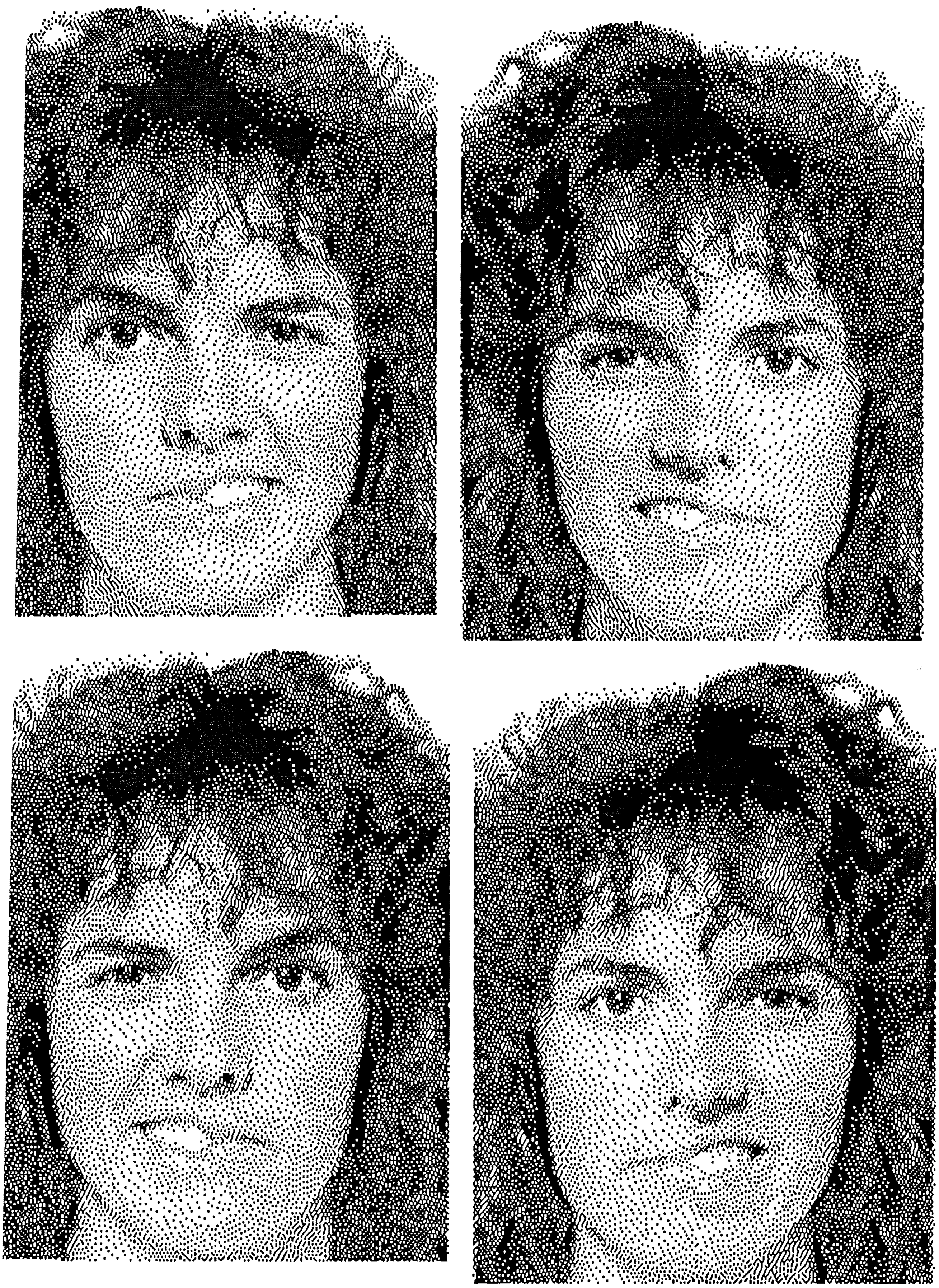
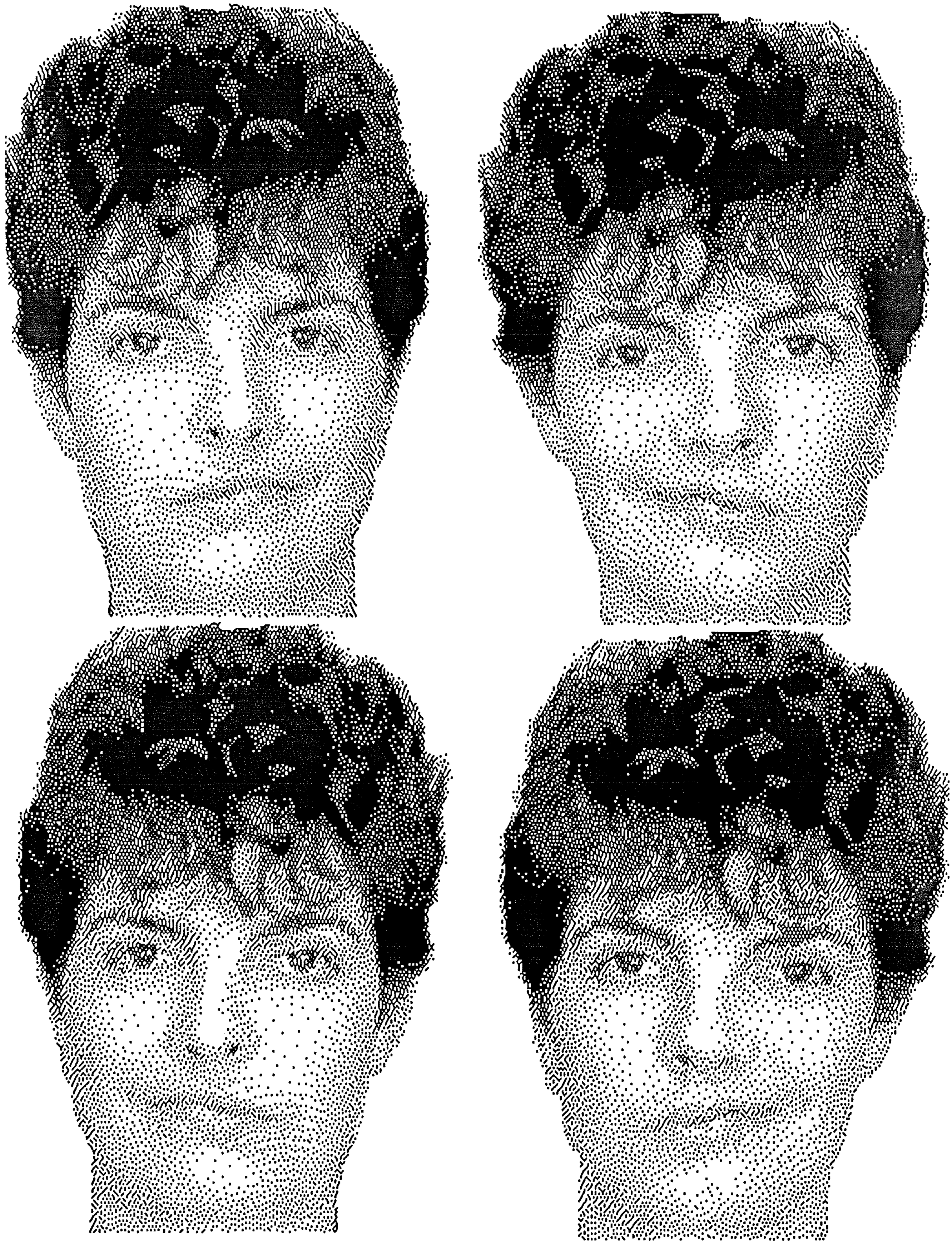




R L

R L





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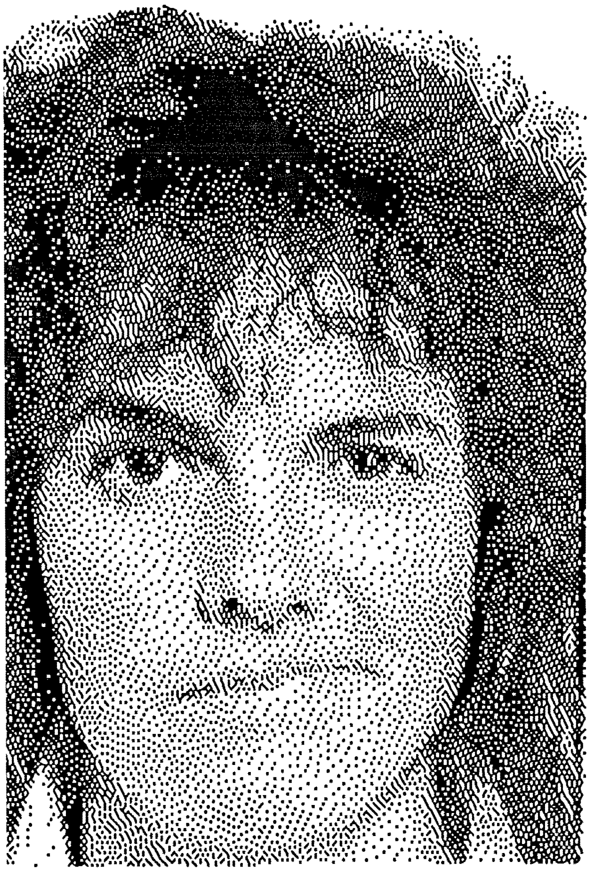
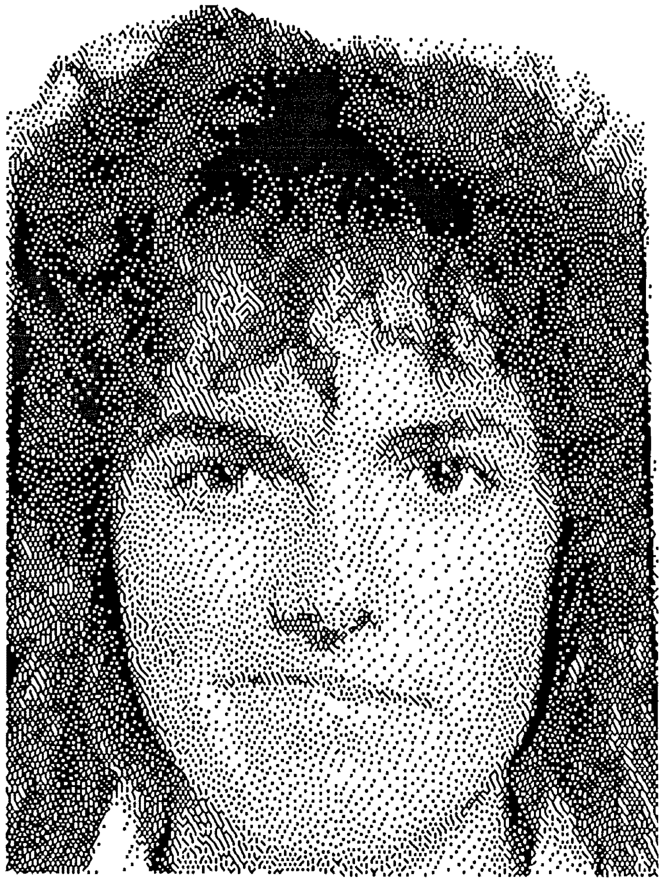


R



L R